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Miss Smarts Book
York Place
Queens Elm, Chelsea
April 18, 1805

# THE
# BOTANIC GARDEN;

## A POEM.

IN TWO PARTS.

BRITISH MUSEUM

THE D—

# BOTANIC GARDEN;

## A POEM,

IN TWO PARTS.

PART I.

CONTAINING THE

## ECONOMY OF VEGETATION.

PART II.

THE

## LOVES OF THE PLANTS.

WITH

PHILOSOPHICAL NOTES.

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BRITISH MUSEUM

# *ADVERTISEMENT.*

THE general deſign of the following ſheets is to inliſt Imagination under the banner of Science; and to lead her votaries from the looſer analogies, which dreſs out the imagery of poetry, to the ſtricter ones, which form the ratiocination of philoſophy. While their particular deſign is to induce the ingenious to cultivate the knowledge of Botany, by introducing them to the veſtibule of that delightful ſcience, and recommending to their attention the immortal works of the celebrated Swediſh Naturaliſt, LINNEUS.

In the firſt Poem, or Economy of Vegetation, the phyſiology of Plants is delivered; and the operation of the Elements, as far as they may be ſuppoſed to affect the growth of Vegetables. In the ſecond Poem, or Loves of the Plants, the Sexual Syſtem of Linneus is explained, with the remarkable properties of many particular plants.

# *APOLOGY.*

IT may be proper here to apologize for many of the ſubſequent conjectures on ſome articles of natural philoſophy, as not being ſupported by accurate inveſtigation or concluſive experiments. Extravagant theories however in thoſe parts of philoſophy, where our knowledge is yet imperfect, are not without their uſe; as they encourage the execution of laborious experiments, or the inveſtigation of ingenious deductions, to confirm or refute them. And ſince natural objects are allied to each other by many affinities, every kind of theoretic diſtribution of them adds to our knowledge by developing ſome of their analogies.

The Roſicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders, was thought to afford a proper machinery for a Botanic poem; as it is probable, that they were originally the names of hieroglyphic figures repreſenting the elements.

Many of the important operations of Nature were ſhadowed or allegorized in the heathen mythology, as the firſt Cupid ſpringing from the

Egg of Night, the marriage of Cupid and Pſyche, the Rape of Proſerpine, the Congreſs of Jupiter and Juno, Death and Reſuſcitation of Adonis, &c. many of which are ingeniouſly explained in the works of Bacon, Vol. V. p. 47. 4th Edit. London, 1778. The Egyptians were poſſeſſed of many diſcoveries in philoſophy and chemiſtry before the invention of letters; theſe were then expreſſed in hieroglyphic paintings of men and animals; which after the diſcovery of the alphabet were deſcribed and animated by the poets, and became firſt the deities of Egypt, and afterwards of Greece and Rome. Alluſions to thoſe fables were therefore thought proper ornaments to a philoſophical poem, and are occaſionally introduced either as repreſented by the poets, or preſerved on the numerous gems and medallions of antiquity.

TO

*THE AUTHOR*

OF THE

# POEM ON THE LOVES OF THE PLANTS.

## BY THE REV. W. B. STEPHENS.

OFT tho' thy genius, D——! amply fraught
With native wealth, explore new worlds of mind;
Whence the bright ores of droſsleſs wiſdom brought,
Stampt by the Muſe's hand, enrich mankind;

Tho' willing Nature to thy curious eye,
Involved in night, her mazy depths betray;
Till at their ſource thy piercing ſearch deſcry
The ſtreams, that bathe with Life our mortal clay;

Tho', boldly ſoaring in ſublimer mood
Through trackleſs ſkies on metaphyſic wings,
Thou dareſt to ſcan the approachleſs Cauſe of Good,
And weigh with ſteadfaſt hand the Sum of Things;

Yet wilt thou, charm'd amid his whiſpering bowers,
Oft with lone ſtep by glittering Derwent ſtray,
Mark his green foliage, count his muſky flowers,
That bluſh or tremble to the riſing ray;

While FANCY, ſeated in her rock-roof'd dell,
Liſtening the ſecrets of the vernal grove,
Breathes ſweeteſt ſtrains to thy ſymphonious ſhell,
And gives new echoes to the throne of Love.

*REPTON, NOV.* 28, 1788.

# ARGUMENT

## OF THE

## FIRST CANTO.

THE Genius of the place invites the Goddeſs of Botany. 1. She deſcends, is received by Spring, and the Elements, 59. Addreſſes the Nymphs of Fire. Star-light Night ſeen in the Camera Obſcura, 81. I. Love created the Univerſe. Chaos explodes. All the Stars revolve. God, 97. II. Shooting Stars. Lightning, Rainbow. Colours of the Morning and Evening Skies. Exterior Atmoſphere of inflammable Air. Twilight. Fire-balls. Aurora Borealis. Planets. Comets. Fixed Stars. Sun's Orb, 115. III. 1. Fires at the Earth's Centre. Animal Incubation, 137. 2. Volcanic Mountains. Venus viſits the Cyclops, 149. IV. Heat confined on the Earth by the Air. Phoſphoric lights in the Evening. Bolognian Stone. Calcined Shells. Memnon's Harp, 173. Ignis fatuus. Luminous Flowers. Glow-worm. Fire-fly. Luminous Sea-inſects. Electric Eel. Eagle armed with Lightning, 189. V. 1. Diſcovery of Fire. Meduſa, 209. 2. The chemical Properties of Fire. Phoſphorus. Lady in Love, 223. 3. Gunpowder, 237. VI. Steam-engine applied to Pumps, Bellows, Water-engines, Corn-mills, Coining, Barges, Waggons, Flying-chariots, 253. Labours of Hercules. Abyla and Calpe, 297. VII. 1. Electric Machine. Heſperian Dragon. Electric kiſs. Halo round the heads of Saints. Electric Shock. Fairy-rings, 335. 2. Death of Profeſſor Richman, 371. 3. Franklin draws Lightning from the Clouds. Cupid ſnatches the Thunder-bolt from Jupiter, 383. VIII Phoſphoric Acid and Vital Heat produced in the Blood. The great Egg of Night, 399. IX. Weſtern Wind unfettered. Naiad releaſed. Froſt aſſailed. Whale attacked, 421. X. Buds and flowers expanded by Warmth, Electricity, and Light.. Drawings with colourleſs ſympathetic Inks; which appear when warmed by the Fire, 457. XI. Sirius. Jupiter and Semele. Northern Conſtellations. Ice-iſlands navigated into the Tropic Seas. Rainy Monſoons, 497. XII. Points erected to procure Rain. Elijah on Mount-Carmel, 547. Departure of the Nymphs of Fire like ſparks from artificial Fireworks, 585.

# THE ECONOMY OF VEGETATION.

## CANTO I.

" STAY *your rude ſteps!* whoſe throbbing breaſts infold
The legion-fiends of Glory, or of Gold!
*Stay!* whoſe falſe lips ſeductive ſimpers part,
While Cunning neſtles in the harlot-heart!—
For you no Dryads dreſs the roſeate bower, 5
For you no Nymphs their ſparkling vaſes pour;
Unmark'd by you, light Graces ſwim the green,
And hovering Cupids aim their ſhafts, unſeen.

" But THOU! whoſe mind the well-attemper'd ray
Of Taſte and Virtue lights with purer day; 10
Whoſe finer ſenſe each ſoft vibration owns
With ſweet reſponſive ſympathy of tones;
So the fair flower expands it's lucid form
To meet the ſun, and ſhuts it to the ſtorm;—

---

*So the fair flower.* l. 13. It ſeems to have been the original deſign of the philoſophy of Epicurus to render the mind exquiſitely ſenſible to agreeable ſenſations, and equally inſenſible to diſagreeable ones.

For thee my borders nurſe the fragrant wreath,
My fountains murmur, and my zephyrs breathe;
Slow ſlides the painted ſnail, the gilded fly
Smooths his fine down, to charm thy curious eye;
On twinkling fins my pearly nations play,
Or win with ſinuous train their trackleſs way;
My plumy pairs in gay embroidery dreſs'd
Form with ingenious bill the penſile neſt,
To Love's ſweet notes attune the liſtening dell,
And Echo ſounds her ſoft ſymphonious ſhell.

“ And, if with Thee ſome hapleſs Maid ſhould ſtray,
Diſaſterous Love companion of her way,
Oh, lead her timid ſteps to yonder glade,
Whoſe arching cliffs depending alders ſhade;
There, as meek Evening wakes her temperate breeze,
And moon-beams glimmer through the trembling trees,
The rills, that gurgle round, ſhall ſoothe her ear,
The weeping rocks ſhall number tear for tear;
There as ſad Philomel, alike forlorn,
Sings to the Night from her accuſtomed thorn;
While at ſweet intervals each falling note
Sighs in the gale, and whiſpers round the grot;
The ſiſter-woe ſhall calm her aching breaſt,
And ſofter ſlumbers ſteal her cares to reſt.—

“ Winds of the North! reſtrain your icy gales,
Nor chill the boſom of theſe happy vales!

---

*Diſaſterous Love.* l. 26. The ſcenery is taken from a botanic garden about a mile from Litchfield, where a cold bath was erected by Sir John Floyer. There is a grotto ſurrounded by projecting rocks, from the edges of which trickles a perpetual ſhower of water; and it is here repreſented as adapted to love-ſcenes, as being thence a proper reſidence for the

Hence in dark heaps, ye gathering Clouds, revolve !
Diſperſe, ye Lightnings ! and, ye Miſts, diſſolve !
—Hither, emerging from yon orient ſkies,
BOTANIC GODDESS ! bend thy radiant eyes;
O'er theſe ſoft ſcenes aſſume thy gentle reign,
Pomona, Ceres, Flora in thy train ;
O'er the ſtill dawn thy placid ſmile effuſe,
And with thy ſilver ſandals print the dews ;
In noon's bright blaze thy vermil veſt unfold,
And wave thy emerald banner ſtar'd with gold."

Thus ſpoke the GENIUS, as He ſtept along,
And bade theſe lawns to Peace and Truth belong ;
Down the ſteep ſlopes He led with modeſt ſkill
The willing pathway, and the truant rill,
Stretch'd o'er the marſhy vale yon willowy mound,
Where ſhines the lake amid the tufted ground,
Raiſed the young woodland, ſmooth'd the wavy green,
And gave to Beauty all the quiet ſcene.—

She comes !--the GODDESS !--through the whiſpering air,
Bright as the morn, deſcends her bluſhing car ;
Each circling wheel a wreath of flowers intwines,
And gem'd with flowers the ſilken harneſs ſhines ;
The golden bits with flowery ſtuds are deck'd,
And knots of flowers the crimſon reins connect.—
And now on earth the ſilver axle rings,
And the ſhell ſinks upon its ſlender ſprings ;
Light from her airy ſeat the Goddeſs bounds,
And ſteps celeſtial preſs the panſied grounds.

---

modern goddeſs of Botany, and the eaſier to introduce the next poem on the Loves of the Plants according to the ſyſtem of Linneus.

Fair Spring advancing calls her feather'd quire,
And tunes to ſofter notes her laughing lyre;
Bids her gay hours on purple pinions move,
And arms her Zephyrs with the ſhafts of Love,
Pleaſed GNOMES, aſcending from their earthy beds,
Play round her graceful footſteps, as ſhe treads;
Gay SYLPHS attendant beat the fragrant air
On winnowing wings, and waft her golden hair;
Blue *Nymphs* emerging leave their ſparkling ſtreams,
And *Fiery Forms* alight from orient beams;
Muſk'd in the roſe's lap freſh dews they ſhed,
Or breathe celeſtial luſtres round her head.

Firſt the fine forms her dulcet voice requires,
Which bathe or baſk in elemental fires;
From each bright gem of Day's refulgent car,
From the pale ſphere of every twinkling ſtar,
From each nice pore of ocean, earth and air,
With eye of flame the ſparkling hoſts repair,
Mix their gay hues, in changeful circles play,
Like motes, that tenant the meridian ray.—
So the clear Lens collects with magic power
The countleſs glories of the midnight hour;
Stars after ſtars with quivering luſtre fall,
And twinkling glide along the whiten'd wall.—

---

*Pleaſed Gnomes*. l. 73. The Roſicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders affords proper machinery for a philoſophic poem; as it is probable that they were originally the names of hieroglyphic figures of the Elements, or of Genii preſiding over their operations. The Fairies of more modern days ſeem to have been derived from them, and to have inherited their powers. The Gnomes and Sylphs, as being more nearly allied to modern Fairies are repreſented as either male or female, which diſtinguiſhes the latter from the Auræ of the Latin Poets, which were only female; except the winds, as Zephyrus and Auſter, may be ſuppoſed to have been their huſbands.

Pleaſed, as they paſs, ſhe counts the glittering bands,
And ſtills their murmur with her waving hands;
Each liſtening tribe with fond expectance burns, 95
And now to theſe, and now to thoſe, ſhe turns.

I. "*Nymphs of primeval Fire! your* veſtal train
Hung with gold-treſſes o'er the vaſt inane,
Pierced with your ſilver ſhafts the throne of Night,
And charm'd young Nature's opening eyes with light; 100
When *Love Divine*, with brooding wings unfurl'd,
Call'd from the rude abyſs the living world.

*Nymphs of primeval fire.* l. 97. The fluid matter of heat is perhaps the moſt extenſive element in nature; all other bodies are immerſed in it, and are preſerved in their preſent ſtate of ſolidity or fluidity by the attraction of their particles to the matter of heat. Since all known bodies are contractible into leſs ſpace by depriving them of ſome portion of their heat, and as there is no part of nature totally deprived of heat, there is reaſon to believe that particles of bodies do not touch, but are held towards each other by their ſelf-attraction, and recede from each other by their attraction to the maſs of heat which ſurrounds them; and thus exiſt in an equilibrium between theſe two powers. If more of the matter of heat be applied to them, they recede further from each other, and become fluid; if ſtill more be applied, they take an aerial form, and are termed Gaſſes by the modern chemiſts. Thus when water is heated to a certain degree, it would inſtantly aſſume the form of ſteam, but for the preſſure of the atmoſphere, which prevents this change from taking place ſo eaſily; the ſame is true of quickſilver, diamonds, and of perhaps all other bodies in Nature; they would firſt become fluid, and then aeriform by appropriated degrees of heat. On the contrary, this elaſtic matter of heat, termed Calorique in the new nomenclature of the French Academicians, is liable to become conſolidated itſelf in its combinations with ſome bodies, as perhaps in nitre, and probably in combuſtible bodies as ſulphur and charcoal. See note on l. 232, of this Canto. Modern philoſophers have not yet been able to decide whether light and heat be different fluids, or modifications of the ſame fluid, as they have many properties in common. See note on l. 468 of this Canto.

*When Love Divine.* l. 101. From having obſerved the gradual evolution of the young animal or plant from its egg or ſeed; and afterwards its ſucceſſive advances to its more perfect ſtate, or maturity; philoſophers

"—*Let there be Light!* proclaim'd the *Almighty* LORD,
Aſtoniſh'd Chaos heard the potent word;—
Through all his realms the kindling Ether runs, 105
And the maſs ſtarts into a million ſuns;

of all ages ſeem to have imagined, that the great world itſelf had likewiſe its infancy and its gradual progreſs to maturity; this ſeems to have given origin to the very antient and ſublime allegory of Eros, or Divine Love, producing the world from the egg of Night, as it floated in Chaos. See l. 419. of this Canto.

The external cruſt of the earth, as far as it has been expoſed to our view in mines or mountains, countenances this opinion; ſince theſe have evidently for the moſt part had their origin from the ſhells of fiſhes, the decompoſition of vegetables, and the recrements of other animal materials, and muſt therefore have been formed progreſſively from ſmall beginnings. There are likewiſe ſome apparently uſeleſs or incomplete appendages to plants and animals, which ſeem to ſhew they have gradually undergone changes from their original ſtate; ſuch as the ſtamens without anthers, and ſtyles without ſtigmas of ſeveral plants, as mentioned in the note on Curcuma, Vol. II. of this work. Such as the halteres, or rudiments of wings of ſome two-winged inſects; and the paps of male animals; thus ſwine have four toes, but two of them are imperfectly formed, and not long enough for uſe. The allantoide in ſome animals ſeems to have become extinct; in others is above tenfold the ſize, which would ſeem neceſſary for its purpoſe. Buffon du Cochon. T. 6. p. 257. Perhaps all the ſuppoſed monſtrous births of Nature are remains of their habits of production in their former leſs perfect ſtate, or attempts towards greater perfection.

*Through all his realms.* l. 105. Mr. Herſchel has given a very ſublime and curious account of the conſtruction of the heavens with his diſcovery of ſome thouſand nebulæ, or clouds of ſtars; many of which are much larger collections of ſtars, than all thoſe put together, which are viſible to our naked eyes, added to thoſe which form the galaxy, or milky zone, which ſurrounds us. He obſerves that in the vicinity of theſe cluſters of ſtars there are proportionally fewer ſtars than in other parts of the heavens; and hence he concludes, that they have attracted each other, on the ſuppoſition that infinite ſpace was at firſt equally ſprinkled with them; as if it had at the beginning been filled with a fluid maſs, which had coagulated. Mr. Herſchel has further ſhewn, that the whole ſidereal ſyſtem is gradually moving round ſome centre, which may be an opake maſs of matter, Philoſ. Tranſ. V. LXXIV. If all theſe Suns are moving round ſome great central body; they muſt have had a projectile force, as well as a centripetal one; and may thence be ſuppoſed to have emerged or been projected from the material, where they were produced. We

Earths round each ſun with quick exploſions burſt,
And ſecond planets iſſue from the firſt;
Bend, as they journey with projectile force,
In bright ellipſes their reluctant courſe;
Orbs wheel in orbs, round centres centres roll,
And form, ſelf-balanced, one revolving Whole.
—Onward they move amid their bright abode,
Space without bound, *the boſom of their* GOD!

II. " *Ethereal Powers! you* chaſe the ſhooting ſtars,
Or yoke the vollied lightenings to your cars,

can have no idea of a natural power, which could project a Sun out of Chaos, except by comparing it to the exploſions or earthquakes owing to the ſudden evolution of aqueous or of other more elaſtic vapours; of the power of which under immeaſurable degrees of heat, and compreſſion, we are yet ignorant.

It may be objected, that if the ſtars had been projected from a Chaos by exploſions, that they muſt have returned again into it from the known laws of gravitation; this however would not happen, if the whole of Chaos, like grains of gunpowder, was exploded at the ſame time, and diſperſed through infinite ſpace at once, or in quick ſucceſſion, in every poſſible direction. The ſame objection may be ſtated againſt the poſſibility of the planets having been thrown from the ſun by exploſions; and the ſecondary planets from the primary ones; which will be ſpoken of more at large in the ſecond Canto, but if the planets are ſuppoſed to have been projected from their ſuns, and the ſecondary from the primary ones, at the beginning of their courſe; they might be ſo influenced or diverted by the attractions of the ſuns, or ſun, in their vicinity, as to prevent their tendency to return into the body, from which they were projected.

If theſe innumerable and immenſe ſuns thus riſing out of Chaos are ſuppoſed to have thrown out their attendant planets by new exploſions, as they aſcended; and thoſe their reſpective ſatellites, filling in a moment the immenſity of ſpace with light and motion, a grander idea cannot be conceived by the mind of man.

*Chaſe the ſhooting ſtars.* l. 115. The meteors called ſhooting ſtars, the lightening, the rainbow, and the clouds, are phenomena of the lower regions of the atmoſphere. The twilight, the meteors call'd fire-balls, or flying dragons, and the northern lights, inhabit the higher regions of the atmoſphere. See additional notes, No. I.

Cling round the aërial bow with priſms bright,
And pleaſed untwiſt the ſevenfold threads of light;
Eve's ſilken couch with gorgeous tints adorn,
And fire the arrowy throne of riſing Morn. 120
—*Or*, plum'd with flame, in gay battalion's ſpring
To brighter regions borne on broader wing;
Where lighter gaſes, circumfuſed on high,
Form the vaſt concave of exterior ſky;

*Cling round the aerial bow.* l. 117. See additional notes, No. II.

*Eve's ſilken couch.* l. 119. See additional notes, No. III.

*Where lighter gaſes.* l. 123. Mr. Cavendiſh has ſhewn, that the gas called inflammable air, is at leaſt ten times lighter than common air; Mr. Lavoiſier contends, that it is one of the component parts of water, and is by him called hydrogene. It is ſuppoſed to afford their principal nouriſhment to vegetables and thence to animals, and is perpetually riſing from their decompoſition; this ſource of it in hot climates, and in ſummer months, is ſo great as to exceed eſtimation. Now if this light gas paſſes through the atmoſphere, without combining with it, it muſt compoſe another atmoſphere over the aerial one; which muſt expand, when the preſſure above it is thus taken away, to inconceiveable tenuity.

If this ſupernatural gaſſeous atmoſphere floats upon the aerial one, like ether upon water, what muſt happen? 1. it will flow from the line, where it will be produced in the greateſt quantities, and become much accumulated over the poles of the earth; 2. the common air, or lower ſtratum, of the atmoſphere, will be much thinner over the poles than at the line; becauſe if a glaſs globe be filled with oil and water, and whirled upon its axis, the centrifugal power will carry the heavier fluid to the circumference, and the lighter will in conſequence be found round the axis. 3. There may be a place at ſome certain latitude between the poles and the line on each ſide the equator, where the inflammable ſupernatant atmoſphere may end, owing to the greater centrifugal force of the heavier aerial atmoſphere. 4. Between the termination of the aerial and the beginning of the gaſſeous atmoſphere, the airs will occaſionally be intermixed, and thus become inflammable by the electric ſpark; theſe circumſtances will aſſiſt in explaining the phenomena of fire-balls, northern lights, and of ſome variable winds, and long continued rains.

Since the above note was firſt written, Mr. Volta, I am informed, has applied the ſuppoſition of a ſupernatant atmoſphere of inflammable air, to explain ſome phenomena in meteorology. And Mr. Lavoiſier has announced his deſign to write on this ſubject. Traitè de Chimie, Tom. I. I am happy to find theſe opinions ſupported by ſuch reſpectable authority.

With airy lens the ſcatter'd rays aſſault, 125
And bend the twilight round the duſky vault;
Ride, with broad eye and ſcintillating hair,
The rapid Fire-ball through the midnight air;
Dart from the North on pale electric ſtreams,
Fringing Night's ſable robe with tranſient beams. 130
—*Or* rein the Planets in their ſwift careers,
Gilding with borrow'd light their twinkling ſpheres;
Alarm with comet-blaze the ſapphire plain,
The wan ſtars glimmering through its ſilver train;
Gem the bright Zodiac, ſtud the glowing pole, 135
Or give the Sun's phlogiſtic orb to roll.

III. *Nymphs! your* fine forms with ſteps impaſſive mock
Earth's vaulted roofs of adamantine rock;
Round her ſtill centre tread the burning ſoil,
And watch the billowy Lavas, as they boil; 140

---

*And bend the twilight.* l. 126. The crepuſcular atmoſphere, or the region where the light of the ſun ceaſes to be refracted to us, is eſtimated by philoſophers to be between 40 and 50 miles high, at which time the ſun is about 18 degrees below the horizon; and the rarity of the air is ſuppoſed to be from 4,000 to 10,000 times greater than at the ſurface of the earth. Cotes's Hydroſt. p. 123. The duration of twilight differs in different ſeaſons and in different latitudes; in England the ſhorteſt twilight is about the beginning of October and of March; in more northern latitudes, where the ſun never ſinks more than 18 degrees, below the horizon, the twilight continues the whole night. The time of its duration may alſo be occaſionally affected by the varying height of the atmoſphere. A number of obſervations on the duration of twilight in different latitudes might afford conſiderable information concerning the aerial ſtrata in the higher regions of the atmoſphere, and might aſſiſt in determining whether an exterior atmoſphere of inflammable gas, or Hydrogene, exiſts over the aerial one.

*Alarm with Comet-blaze.* l. 133. See additional notes, No. IV.

*The Sun's phlogiſtic orb.* l. 136. See additional notes, No. V.

*Round her ſtill centre.* l. 139. Many philoſophers have believed that the central parts of the earth conſiſt of a fluid maſs of burning lava, which they have called a ſubterraneous ſun; and have ſuppoſed, that it contributes to the production of metals, and to the growth of vegetables. See additional notes, No. VI.

Where, in baſaltic caves impriſon'd deep,
Reluctant fires in dread ſuſpenſion ſleep;
Or ſphere on ſphere in widening waves expand,
And glad with genial warmth the incumbent land.
So when the Mother-bird ſelects their food 145
With curious bill, and feeds her callow brood;
Warmth from her tender heart eternal ſprings,
And pleaſed ſhe claſps them with extended wings.

"*You* from deep cauldrons and unmeaſured caves
Blow flaming airs, or pour vitreſcent waves; 150
O'er ſhining oceans ray volcanic light,
Or hurl innocuous embers to the night.—
While with loud ſhouts to Etna Heccla calls,
And Andes anſwers from his beacon'd walls;

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*Or ſphere on ſphere.* l. 143. See additional notes, No. VII.

*Hurl innocuous embers.* l. 152. The immediate cauſe of volcanic eruptions is believed to be owing to the water of the ſea, or from lakes, or inundations, finding itſelf a paſſage into the ſubterraneous fires, which may lie at great depths. This muſt firſt produce by its coldneſs a condenſation of the vapour there exiſting, or a vacuum, and thus occaſion parts of the earth's cruſt or ſhell to be forced down by the preſſure of the incumbent atmoſphere. Afterwards the water being ſuddenly raiſed into ſteam produces all the exploſive effects of earthquakes. And by new acceſſions of water during the intervals of the exploſions the repetition of the ſhocks is cauſed. Theſe circumſtances were hourly illuſtrated by the fountains of boiling water in Iceland, in which the ſurface of the water in the boiling wells ſunk down low before every new ebullition.

Beſides theſe eruptions occaſioned by the ſteam of water, there ſeems to be a perpetual effuſion of other vapours, more noxious and (as far as it is yet known) perhaps greatly more expanſile than water from the Volcanos in various parts of the world. As theſe Volcanos are ſuppoſed to be ſpiracula or breathing holes to the great ſubterraneous fires, it is probable that the eſcape of elaſtic vapours from them is the cauſe, that the earthquakes of modern days are of ſuch ſmall extent compared to thoſe of antient times, of which veſtiges remain in every part of the world, and on this account may be ſaid not only to be innocuous, but uſeful.

Sea-wilder'd crews the mountain-ſtars admire,
And Beauty beams amid tremendous fire.

"Thus when of old, as myſtic bards preſume,
Huge CYCLOPS dwelt in Etna's rocky womb,
On thundering anvils rung their loud alarms,
And leagued with VUCLAN forged immortal arms;
Deſcending VENUS ſought the dark abode,
And ſooth'd the labours of the griſly God.—
While frowning Loves the threatening falchion wield,
And tittering Graces peep behind the ſhield,
With jointed mail their fairy limbs o'erwhelm,
Or nod with pauſing ſtep the plumed helm;
With radiant eye She view'd the boiling ore,
Heard undiſmay'd the breathing bellows roar,
Admired their ſinewy arms, and ſhoulders bare,
And ponderous hammers lifted high in air,
With ſmiles celeſtial bleſs'd their dazzled ſight,
And Beauty blazed amid infernal night.

IV. *Effulgent Maids! you* round deciduous day,
Treſſed with ſoft beams, your glittering bands array;
On Earth's cold boſom, as the Sun retires,
Confine with folds of air the lingering fires;

*Confine with folds of air.* l. 174. The air, like all other bad conductors of electricity, is known to be a bad conductor of heat; and thence prevents the heat acquired from the ſun's rays by the earth's ſurface from being ſo ſoon diſſipated, in the ſame manner as a blanket, which may be conſidered as a ſponge filled with air, prevents the eſcape of heat from the perſon wrapped in it. This ſeems to be one cauſe of the great degree of cold on the tops of mountains, where the rarity of the air is greater, and it therefore becomes a better conductor both of heat and electricity. See note on Barometz, Vol. II. of this work.

There is however another cauſe to which the great coldneſs of mountains and of the higher regions of the atmoſphere is more immediately to be aſcribed, explained by Dr. Darwin in the Philoſ. Tranſ.

O'er Eve's pale forms diffuſe phoſphoric light,
And deck with lambent flames the ſhrine of Night.
So, warm'd and kindled by meridian ſkies,
And view'd in darkneſs with dilated eyes, 180
BOLOGNA's chalks with faint ignition blaze,
BECCARI's ſhells emit priſmatic rays.

Vol. LXXVIII. who has there proved by experiments with the air-gun and air-pump, that when any portion of the atmoſphere becomes mechanically expanded, it abſorbs heat from the bodies in its vicinity. And as the air which creeps along the plains, expands itſelf by a part of the preſſure being taken off when it aſcends the ſides of mountains; it at the ſame time attracts heat from the ſummits of thoſe mountains, or other bodies which happen to be immerſed in it, and thus produces colds. Hence he concludes that the hot air at the bottom of the Andes becomes temperate by its own rarefaction when it aſcends to the city of Quito; and by its further rarefaction becomes cooled to the freezing point when it aſcends to the ſnowy regions on the ſummits of thoſe mountains. To this alſo he attributes the great degree of cold experienced by the aeronauts in their balloons: and which produces hail in ſummer at the height of only two or three miles in the atmoſphere.

*Diffuſe phoſphoric light.* l. 177. I have often been induced to believe from obſervation, that the twilight of the evenings is lighter than that of the mornings at the ſame diſtance from noon. Some may aſcribe this to the greater height of the atmoſphere in the evenings having been rarefied by the ſun during the day; but as its denſity muſt at the ſame time be diminiſhed, its power of refraction would continue the ſame. I ſhould rather ſuppoſe that it may be owing to the phoſphoreſcent quality (as it is called) of almoſt all bodies; that is, when they have been expoſed to the ſun they continue to emit light for a conſiderable time afterwards. This is generally believed to ariſe either from ſuch bodies giving out the light which they had previouſly abſorbed; or to the countenance of a ſlow combuſtion which the light they had been previouſly expoſed to had excited. See the next note.

*Beccari's ſhells.* l. 182. Beccari made many curious experiments on the phoſphoric light, as it is called, which becomes viſible on bodies brought into a dark room, after having been previouſly expoſed to the ſunſhine. It appears from theſe experiments, that almoſt all infammable bodies poſſeſs this quality in a greater or leſs degree; white paper or linen thus examined after having been expoſed to the ſunſhine, is luminous to an extraordinary degree; and if a perſon ſhut up in a dark room, puts one of his hands out into the ſun's light for a ſhort time, and then retracts it, he will be able to ſee that hand diſtinctly, and not the other.

So to the ſacred Sun in Memnon's fane,
Spontaneous concords quired the matin ſtrain;
—Touch'd by his orient beam, reſponſive rings
The living lyre, and vibrates all it's ſtrings;
Accordant ailes the tender tones prolong,
And holy echoes ſwell the adoring ſong.

"You with light Gas the lamps nocturnal feed,
Which dance and glimmer o'er the marſhy mead;

Theſe experiments ſeem to countenance the idea of light being abſorbed and again emitted from bodies when they are removed into darkneſs. But Beccari further pretended, that ſome calcareous compoſitions when expoſed to red, yellow, or blue light, through coloured glaſſes, would on their being brought into a dark room emit coloured lights. This miſtaken fact of Beccari's, Mr. Wilſon decidedly refutes; and among many other curious experiments diſcovered, that if oyſter-ſhells were thrown into a common fire and calcined for about half an hour, and then brought to a perſon who had previouſly been ſome minutes in a dark room, that many of them would exhibit beautiful iriſes of priſmatic colours, from whence probably aroſe Beccari's miſtake. Mr. Wilſon from hence contends, that theſe kinds of phoſphori do not emit the light they had previouſly received, but that they are ſet on fire by the ſun's rays, and continue for ſome time a ſlow combuſtion after they are withdrawn from the light. Wilſon's experiments on Phoſphori. Dodſley, 1775.

The Bolognian ſtone is a ſelenite, or gypſum, and has been long celebrated for its phoſphoreſcent quality after having been burnt in a ſulphurous fire; and expoſed when cold to the ſun's light. It may be thus well imitated: Calcine oyſter-ſhells half an hour, pulverize them when cold, and add one third part of flowers of ſulphur, preſs them cloſe into a ſmall crucible, and calcine them for an hour or longer, and keep the powder in a phial cloſe ſtopped. A part of this powder is to be expoſed for a minute or two to the ſunbeams, and then brought into a dark room. The calcined Bolognian ſtone becomes a calcareous hepar of ſulphur; but the calcined ſhells, as they contain the animal acid may alſo contain ſome of the phoſphorus of Kunkel.

*In Memnon's fane.* l. 183. See additional notes. No. VIII.

*The lamps nocturnal.* l. 189. The ignis fatuus or Jack a lantern, ſo frequently alluded to by poets, is ſuppoſed to originate from the inflammable air, or Hydrogene, given up from moraſſes; which being of heavier kind from its impurity than that obtained from iron and water, hovers near the ſurface of the earth, and uniting with common air gives out light by its ſlow ignition. Perhaps ſuch lights have no exiſtence, and

Shine round Calendula at twilight hours,
And tip with ſilver all her ſaffron flowers;
Warm on her moſſy couch the radiant Worm,
Guard from cold dews her love-illumin'd form,
From leaf to leaf conduct the virgin light, 195
Star of the earth, and diamond of the night.
*You* bid in air the tropic Beetle burn,
And fill with golden flame his winged urn:
Or gild the ſurge with inſect-ſparks, that ſwarm
Round the bright oar, the kindling prow alarm; 200
Or arm in waves, electric in his ire,
The dread Gymnotus with ethereal fire.—
Onward his courſe with waving tail he helms,
And mimic lightenings ſcare the watery realms,

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the reflection of a ſtar on watery ground may have deceived the travellers, who have been ſaid to be bewildered by them? if the fact was eſtabliſhed it would much contribute to explain the phenomena of northern lights. I have travelled much in the night, in all ſeaſons of the year, and over all kinds of ſoil, but never ſaw one of theſe Will o'wiſps.

*Shine round Calendula.* l. 191. See note on Tropæolum in Vol. II.

*The radiant Worm.* l. 193. See additional notes, No. IX.

*The dread Gymnotus.* l. 202. The Gymnotus electricus is a native of the river of Surinam in South America; thoſe which were brought over to England about eight years ago were about three or four feet long, and gave an electric ſhock (as I experienced) by putting one finger on the back near its head, and another of the oppoſite hand into the water near its tail. In their native country they are ſaid to exceed twenty feet in length, and kill any man who approaches them in an hoſtile manner. It is not only to eſcape its enemies that this ſurprizing power of the fiſh is uſed, but alſo to take its prey; which it does by benumbing them and then devouring them before they have time to recover, or by perfectly killing them; for the quantity of the power ſeemed to be determined by the will or anger of the animal; as it ſometimes ſtruck a fiſh twice before it was ſufficiently benumbed to be eaſily ſwallowed.

The organs productive of this wonderful accumulation of electric matter have been accurately diſſected and deſcribed by Mr. J. Hunter Philoſ. Tranſ. Vol. LXV. And are ſo divided by membranes as to compoſe a very extenſive ſurface, and are ſupplied with many pairs of

So, when with briſtling plumes the Bird of JOVE 205
Vindictive leaves the argent fields above,
Borne on broad wings the guilty world he awes,
And graſps the lightening in his ſhining claws.

V. 1. "*Nymphs! your* ſoft ſmiles uncultur'd man ſubdued,
And charm'd the Savage from his native wood; 210

nerves larger than any other nerves of the body; but how ſo large a quantity is ſo quickly accumulated as to produce ſuch amazing effects in a fluid ill adapted for the purpoſe is not yet ſatisfactorily explained. The Torpedo poſſeſſes a ſimilar power in a leſs degree, as was ſhewn by Mr. Walch, and another fiſh lately deſcribed by Mr. Paterſon. Philoſ. Tranſ. Vol. LXXVI.

In the conſtitution of the Leyden-Phial, (as it is called) which is coated on both ſides, it is known, that above one hundred times the quantity of poſitive electricity can be condenſed on every ſquare inch of the coating on one ſide, than could have been accumulated on the ſame ſurface if there had been no oppoſite coating communicating with the earth; becauſe the negative electricity, or that part of it which cauſed its expanſion, is now drawn off through the glaſs. It is alſo well known, that the thinner the glaſs is (which is thus coated on both ſides ſo as to make a Leyden-phial, or plate) the more electricity can be condenſed on one of its ſurfaces, till it becomes ſo thin as to break, and thence diſcharge itſelf.

Now it is poſſible, that the quantity of electricity condenſible on one ſide of a coated phial may increaſe in ſome high ratio in reſpect to the thinneſs of the glaſs, ſince the power of attraction is known to decreaſe as the ſquares of the diſtances, to which this circumſtance of electricity ſeems to bear ſome analogy. Hence if an animal membrane, as thin as the ſilk-worm ſpins its ſilk, could be ſo ſituated as to be charged like the Leyden bottle, without burſting, (as ſuch thin glaſs would be liable to do,) it would be difficult to calculate the immenſe quantity of electric fluid, which might be accumulated on its ſurface. No land animals are yet diſcovered which poſſeſs this power, though the air would have been a much better medium for producing its effects; perhaps the ſize of the neceſſary apparatus would have been inconvenient to land animals.

*In his ſhining claws*. l. 208. Alluding to an antique gem in the collection of the Grand Duke of Florence. Spence.

*You*, while amazed his hurrying Hords retire
From the fell havoc of devouring *Fire*,
Taught, the firſt Art! with piny rods to raiſe
By quick attrition the domeſtic blaze,
Fan with ſoft breath, with kindling leaves provide, 215
And liſt the dread deſtroyer on his ſide.
So, with bright wreath of ſerpent-treſſes crown'd,
Severe in beauty, young MEDUSA frown'd:

*Of devouring fire.* l. 212. The firſt and moſt important diſcovery of mankind ſeems to have been that of fire. For many ages it is probable fire was eſteemed a dangerous enemy, known only by its dreadful devaſtations; and that many lives muſt have been loſt, and many dangerous burns and wounds muſt have afflicted thoſe who firſt dared to ſubject it to the uſes of life. It is ſaid that the tall monkies of Borneo and Sumatra lie down with pleaſure round any accidental fire in their woods; and are arrived to that degree of reaſon, that knowledge of cauſation, that they thruſt into the remaining fire the half-burnt ends of the branches to prevent its going out. One of the nobles of the cultivated people of Otaheita, when Captain Cook treated them with tea, catched the boiling water in his hand from the cock of the tea-urn, and bellowed with pain, not conceiving that water could become hot, like red fire.

Tools of ſteel conſtitute another important diſcovery in conſequence of fire; and contributed perhaps principally to give the European nations ſo great ſuperiority over the American world. By theſe two agents, fire and tools of ſteel, mankind became able to cope with the vegetable kingdom, and conquer provinces of foreſts, which in uncultivated countries almoſt exclude the growth of other vegetables, and of thoſe animals which are neceſſary to our exiſtence. Add to this, that the quantity of our food is alſo increaſed by the uſe of fire, for ſome vegetables become ſalutary food by means of the heat uſed in cookery, which are naturally either noxious or difficult of digeſtion; as potatoes, kidney-beans, onions, cabbages, The caſſava when made into bread, is perhaps rendered mild by the heat it undergoes, more than by expreſſing its ſuperfluous juice. The roots of white bryony and of arum, I am informed, loſe much of their acrimony by boiling.

*Young Meduſa frowned.* l. 218. The Egyptian Meduſa is repreſented on antient gems with wings on her head, ſnaky hair, and a beautiful countenance, which appears intenſely thinking; and was ſuppoſed to repreſent divine wiſdom. The Grecian Meduſa, on Minerva's ſhield, as appears on other gems, has a countenance diſtorted with rage or pain, and is ſuppoſed to repreſent divine vengeance. This Meduſa was one of the Gorgons, at firſt very beautiful and terrible to her enemies: Minerva turned

Erewhile ſubdued, round *Wiſdom's* Ægis roll'd
Hiſs'd the dread ſnakes, and flam'd in burniſh'd gold;
Flaſh'd on her brandiſh'd arm the immortal ſhield,
And terror lighten'd o'er the dazzled field.

2. *Nymphs! you* disjoin, unite, condenſe, expand,
And give new wonders to the Chemiſt's hand;
On tepid clouds of riſing ſteam aſpire,
Or fix in ſulphur all it's ſolid fire;
With boundleſs ſpring elaſtic airs unfold,
Or fill with fine vacuities of gold;

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her hair into ſnakes, and Perſeus having cut off her head fixed it on the ſhield of that goddeſs; the ſight of which then petrified the beholders. Dannet. Dict.

*Or fix in ſulphur.* l. 226. The phenomena of chemical exploſions cannot be accounted for without the ſuppoſition, that ſome of the bodies employed contain concentrated or ſolid heat combined with them, to which the French Chemiſts have given the name of Calorique. When air is expanded in the air-pump, or water evaporated into ſteam, they drink up or abſorb a great quantity of heat; from this analogy, when gunpowder is exploded it ought to abſorb much heat, that is, in popular language, it ought to produce a great quaintity of cold. When vital air is united with phlogiſtic matter in reſpiration, which ſeems to be a ſlow cumbuſtion, its volume is leſſened; the carbonic acid, and perhaps phoſphoric acid are produced; and heat is given out; which according to the experiments of Dr. Crawford would ſeem to be depoſited from the vital air. But as the vital air in nitrous acid is condenſed from a light elaſtic gas to that of a heavy fluid, it muſt poſſeſs leſs heat than before. And hence a great part of the heat, which is given out in firing gunpowder, I ſhould ſuppoſe, muſt reſide in the ſulphur or charcoal.

Mr. Lavoiſier has ſhewn, that vital air, or Oxygene, loſes leſs of its heat when it becomes one of the component parts of nitrous acid, than in any other of its combinations; and is hence capable of giving out a great quantity of heat in the exploſion of gunpowder; but as there ſeems to be great analogy between the matter of heat, or Calorique, and the electric matter; and as the worſt conductors of electricity are believed to contain the greateſt quantity of that fluid: there is reaſon to ſuſpect that the worſt conductors of heat may contain the moſt of that fluid; as ſulphur, wax, ſilk, air, glaſs. See note on l. 174 of this Canto.

With ſudden flaſh vitreſcent ſparks reveal,
By fierce colliſion from the flint and ſteel;
Or mark with ſhining letters KUNKEL's name
In the pale Phoſphor's ſelf-conſuming flame.
So the chaſte heart of ſome enchanted Maid
Shines with inſidious light, by Love betray'd;
Round her pale boſom plays the young Deſire,
And ſlow ſhe waſtes by ſelf-conſuming fire.

3. "*You* taught myſterious BACON to explore
Metallic veins, and part the droſs from ore;
With ſylvan coal in whirling mills combine
The cryſtal'd nitre, and the ſulphurous mine;
Through wiry nets the black diffuſion ſtrain,
And cloſe an airy ocean in a grain.—

*Vitreſcent ſparks*. l. 229. When flints are ſtruck againſt other flints they have the property of giving ſparks of light; but it ſeems to be an internal light, perhaps of electric origin, very different from the ignited ſparks which are ſtruck from flint and ſteel. The ſparks produced by the colliſion of ſteel with flint appear to be globular particles of iron, which have been fuſed, and imperfectly ſcorified or vitrified. They are kindled by the heat produced by the colliſion; but their vivid light, and their fuſion and vitrification are the effects of a combuſtion continued in theſe particles during their paſſage through the air. This opinion is confirmed by an experiment of Mr. Hawkſbee, who found that theſe ſparks could not be produced in the exhauſted receiver. See Keir's Chemical Dict. art. Iron, and art. Earth vitrifiable.

*The pale Phoſphor*. l. 232. See additional notes, No. X.

*And cloſe an airy ocean*. l. 242. Gunpowder is plainly deſcribed in the works of Roger Bacon before the year 1267. He deſcribes it in a curious manner, mentioning the ſulphur and nitre, but conceals the charcoal in an anagram. The words are, ſed tamen ſalis petræ *lure mope can ubre*, et ſulphuris; et ſic facies tonitrum, et corruſcationem, ſi ſcias, artificium. The words lure mope can ubre are an anagram of carbonum pulvere. Biograph. Britan. Vol. I. Bacon de Secretis Operibus, Cap. XI. He adds, that he thinks by an artifice of this kind Gideon defeated the Midianites with only three hundred men. Judges, Chap. VII. Chamb. Dict. art. Gunpowder. As Bacon does not claim this as his own invention, it is thought by many to have been of much more antient diſcovery.

Pent in dark chambers of cylindric braſs,
Slumbers in grim repoſe the ſooty maſs;
Lit by the brilliant ſpark, from grain to grain
Runs the quick fire along the kindling train;
On the pain'd ear-drum burſts the ſudden craſh,
Starts the red flame, and Death purſues the flaſh.—
Fear's feeble hand directs the fiery darts,
And Strength and Courage yields to chemic arts;
Guilt with pale brow the mimic thunder owns,
And Tyrants tremble on their blood-ſtain'd thrones.

VI. *Nymphs! you* erewhile on ſimmering cauldrons play'd,
And call'd delighted *Savery* to your aid;
Bade round the youth exploſive *Steam* aſpire
In gathering clouds, and wing'd the wave with fire;

The permanently elaſtic fluid generated in the firing of gunpowder is calculated by Mr. Robins to be about 244 if the bulk of the powder be 1. And that the heat generated at the time of the exploſion occaſions the rarefied air thus produced to occupy about 1000 times the ſpace of the gunpowder. This preſſure may therefore be called equal to 1000 atmoſpheres or ſix tons upon a ſquare inch. As the ſuddenneſs of this exploſion muſt contribute much to its power, it would ſeem that the chamber of powder, to produce its greateſt effect, ſhould be lighted in the centre of it; which I believe is not attended to in the manufacture of muſkets or piſtols.

From the cheapneſs with which a very powerful gunpowder is likely ſoon to be manufactured from aerated marine acid, or from a new method of forming nitrous acid by means of mangoneſe or other calciform ores, it may probably in time be applied to move machinery, and ſuperſede the uſe of ſteam.

There is a better invective in Don Quixote againſt the inventors of gunpowder, as it levels the ſtrong with the weak, the knight caſed in ſteel with the naked ſhepherd, thoſe who have been trained to the ſword, with thoſe who are totally unſkilful in the uſe of it; and throws down all the ſplendid diſtinctions of mankind. Theſe very reaſons ought to have been urged to ſhew that the diſcovery of gunpowder has been of public utility by weakening the tyranny of the few over the many.

*Delighted Savery*. l. 254. The invention of the ſteam-engine for raiſing water by the preſſure of the air in conſequence of the condenſation of

Bade the cold ſtreams the quick expanſion ſtop,
And ſunk the immenſe of vapour to a drop.—
Preſs'd by the ponderous air the Piſton falls
Reſiſtleſs, ſliding through it's iron walls;
Quick moves the balanced beam, of giant-birth,
Wields his large limbs, and nodding ſhakes the earth.

"The Giant-Power from earth's remoteſt caves
Lifts with ſtrong arm her dark reluctant waves;
Each cavern'd rock, and hidden den explores,
Drags her dark coals, and digs her ſhining ores.—
Next, in cloſe cells of ribbed oak confined,
Gale after gale, He crouds the ſtruggling wind;
The impriſon'd ſtorms through brazen noſtrils roar,
Fan the white flame, and fuſe the ſparkling ore.
Here high in air the riſing ſtream He pours
To clay-built ciſterns, or to lead-lined towers;
Freſh through a thouſand pipes the wave diſtils,
And thirſty cities drink the exuberant rills.—
There the vaſt mill-ſtone with inebriate whirl
On trembling floors his forceful fingers twirl.

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ſteam, is properly aſcribed to Capt. Savery; a plate and deſcription of this machine is given in Harris's Lexicon Technicum, art. Engine. Though the Marquis of Worceſter in his Century of Inventions printed in the year 1663 had deſcribed an engine for raiſing water by the exploſive power of ſteam long before Savery's. Mr. Deſegulier affirms, that Savery bought up all he could procure of the books of the Marquis of Worceſter, and deſtroyed them, profeſſing himſelf then to have diſcovered the power of ſteam by accident, which ſeems to have been an unfounded ſlander. Savery applied it to the raiſing of water to ſupply houſes and gardens, but could not accompliſh the draining of mines by it. Which was afterwards done by Mr. Newcomen and Mr. John Cowley at Dartmouth, in the year 1712, who added the piſton.

A few years ago Mr. Watt of Glaſgow much improved this machine, and with Mr. Boulton of Birmingham has applied it to variety of purpoſes, ſuch as raiſing water from mines, blowing bellows to fuſe the ore, ſupplying towns with water, grinding corn and many other purpoſes.

Whoſe flinty teeth the golden harveſts grind,
Feaſt without blood! and nouriſh human-kind.

“ Now his hard hands on Mona's rifted creſt,
Boſom'd in rock, her azure ores arreſt; 280
With iron lips his rapid rollers ſeize
The lengthening bars, in thin expanſion ſqueeze;

There is reaſon to believe it may in time be applied to the rowing of barges, and the moving of carriages along the road. As the ſpecific levity of air is too great for the ſupport of great burthens by balloons, there ſeems no probable method of flying conveniently but by the power of ſteam, or ſome other exploſive material; which another half century may probably diſcover. See additional notes, No. XI.

*Feaſt without blood!* l. 278. The benevolence of the great Author of all things is greatly manifeſt in the ſum of his works, as Dr. Balguy has well evinced in his pamphlet on Divine Benevolence aſſerted, printed for Davis, 1781. Yet if we may compare the parts of nature with each other, there are ſome circumſtances of her economy which ſeem to contribute more to the general ſcale of happineſs than others. Thus the nouriſhment of animal bodies is derived from three ſources: 1. the milk given from the mother to the offspring; in this excellent contrivance the mother has pleaſure in affording the ſuſtenance to the child, and the child has pleaſure in receiving it. 2. Another ſource of the food of animals includes ſeeds or eggs; in theſe the embryon is in a torpid or inſenſible ſtate, and there is along with it laid up for its early nouriſhment a ſtore of proviſion, as the fruit belonging to ſome ſeeds, and the oil and ſtarch belonging to others; when theſe are conſumed by animals the unfeeling ſeed or egg receives no pain, but the animal receives pleaſure which conſumes it. Under this article may be included the bodies of animals which die naturally. 3. But the laſt method of ſupporting animal bodies by the deſtruction of other living animals, as lions preying upon lambs, theſe upon living vegetables, and mankind upon them all, would appear to be a leſs perfect part of the economy of nature than thoſe before mentioned, as contributing leſs to the ſum of general happineſs.

*Mona's rifted creſt.* 279. Alluding to the very valuable copper-mines in the iſle of Angleſey, the property of the Earl of Uxbridge.

*With iron-lips.* l. 281. Mr. Boulton has lately conſtructed at Soho near Birmingham, a moſt magnificent apparatus for Coining, which has coſt him ſome thouſand pounds; the whole machinery is moved by an improved ſteam-engine, which rolls the copper for half-pence finer than copper has before been rolled for the purpoſe of making money; it works the

Deſcending ſcrews with ponderous fly-wheels wound
The tawny plates, the new medallions round;
Hard dyes of ſteel the cupreous circles cramp,
And with quick fall his maſſy hammers ſtamp.
The Harp, the Lily and the Lion join,
And GEORGE and BRITAIN guard the ſterling coin.

" Soon ſhall thy arm, *Unconquer'd Steam!* afar
Drag the ſlow barge, or drive the rapid car;
Or on wide-waving wings expanded bear
The flying-chariot through the fields of air.
—Fair crews triumphant, leaning from above,
Shall wave their fluttering kerchiefs as they move;
Or warrior-bands alarm the gaping croud,
And armies ſhrink beneath the ſhadowy cloud.

" So mighty HERCULES o'er many a clime
Waved his vaſt mace in Virtue's cauſe ſublime,
Unmeaſured ſtrength with early art combined,
Awed, ſerved, protected, and amazed mankind.—

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coupoirs or ſcrew-preſſes for cutting out the circular pieces of copper; and coins both the faces and edges of the money at the ſame time, with ſuch ſuperior excellence and cheapneſs of workmanſhip, as well as with marks of ſuch powerful machinery as muſt totally prevent clandeſtine imitation, and in conſequence ſave many lives from the hand of the executioner; a circumſtance worthy the attention of a great miniſter. If a civic crown was given in Rome for preſerving the life of one citizen, Mr. Boulton ſhould be covered with garlands of oak! By this machinery four boys of ten or twelve years old are capable of ſtriking thirty thouſand guineas in an hour, and the machine itſelf keeps an unerring account of the pieces ſtruck.

*So mighty Hercules.* l. 297. The ſtory of Hercules ſeems of great antiquity, as appears from the ſimplicity of his dreſs and armour, a lion's ſkin and a club; and from the nature of many of his exploits the deſtruction of wild beaſts and robbers. This part of the hiſtory of Hercules ſeems to have related to times before the invention of the bow and arrow, or of ſpinning flax. Other ſtories of Hercules are perhaps of later date, and appear to be allegorical, as his conquering the river-god Achilous, and

Firſt two dread Snakes at JUNO's vengeful nod
Climb'd round the cradle of the ſleeping God;
Waked by the ſhrilling hiſs, and ruſtling ſound,
And ſhrieks of fair attendants trembling round,
Their gaſping throats with clenching hands he holds;
And Death untwiſts their convoluted folds. 306
Next in red torrents from her ſevenfold heads
Fell HYDRA's blood on Lerna's lake he ſheds;
Graſps ACHELOUS with reſiſtleſs force,
And drags the roaring River to his courſe; 310
Binds with loud bellowing and with hideous yell
The monſter Bull, and threefold Dog of Hell.

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bringing Cerberus up to day light; the former might refer to his turning the courſe of a river, and draining a moraſs, and the latter to his expoſing a part of the ſuperſtition of the times. The ſtrangling the lion and tearing his jaws aſunder, are deſcribed from a ſtatue in the Muſeum Florentinum, and from an antique gem; and the graſping Anteus to death in his arms as he lifts him from the earth, is deſcribed from another antient cameo. The famous pillars of Hercules have been variouſly explained. Pliny aſſerts that the natives of Spain and of Africa believed that the mountains of Abyla and Calpè on each ſide of the ſtraits of Gibraltar were the pillars of Hercules; and that they were reared by the hands of that god, and the ſea admitted between them. Plin. Hiſt. Nat. p. 46. Edit. Manut. Venet. 1609.

If the paſſage between the two continents was opened by an earthquake in antient times, as this allegorical ſtory would ſeem to countenance, there muſt have been an immenſe current of water at firſt run into the Mediterranean from the Atlantic; ſince there is at preſent a ſtrong ſtream ſets always from thence into the Mediterranean. Whatever may be the cauſe, which now conſtantly operates, ſo as to make the ſurface of the Mediterranean lower than that of the Atlantic, it muſt have kept it very much lower before a paſſage for the water through the ſtreights was opened. It is probable before ſuch an event took place, the coaſts and iſlands of the Mediterranean extended much further into that ſea, and were then for a great extent of country, deſtroyed by the floods occaſioned by the new riſe of water, and have ſince remained beneath the ſea. Might not this give riſe to the flood of Deucalion? See note Caſſia, V. II. of this work.

" Then where Nemea's howling foreſts wave,
He drives the Lion to his duſky cave ;
Seized by the throat the growling fiend diſarms,
And tears his gaping jaws with ſinewy arms :
Liſts proud ANTEUS from his mother-plains,
And with ſtrong graſp the ſtruggling Giant ſtrains;
Back falls his fainting head, and clammy hair,
Writhe his weak limbs, and flits his life in air;—
By ſteps reverted o'er the blood-drop'd ſen
He tracks huge CACUS to his murderous den ;
Where breathing flames through brazen lips he fled,
And ſhakes the rock-roof'd cavern o'er his head.

" Laſt with wide arms the ſolid earth He tears,
Piles rock on rock, on mountain mountain rears;
Heaves up huge *Abyla* on Afric's ſand,
Crowns with high *Calpè* Europe's ſaliant ſtrand,
Creſts with oppoſing towers the ſplendid ſcene,
And pours from urns immenſe the ſea between.—
—Loud o'er her whirling flood Charybdis roars,
Affrighted Scylla bellows round his ſhores,
Veſuvio groans through all his echoing caves,
And Etna thunders o'er the inſurgent waves.

VII. 1. *Nymphs ! your* fine hands ethereal floods amaſs
From the warm cuſhion, and the whirling glaſs ;
Beard the bright cylinder with golden wire,
And circumfuſe the gravitating fire.

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*Ethereal floods amaſs.* l. 335. The theory of the accumulation of the electric fluid by means of the glaſs-globe and cuſhion is difficult to comprehend. Dr. Franklin's idea of the pores of the glaſs being opened by the friction, and thence rendered capable of attracting more electric fluid, which it again parts with, as the pores contract again, ſeems analogous in ſome meaſure to the heat produced by the vibration, or condenſation of

Cold ſrom each point cerulean luſtres gleam,
Or ſhoot in air the ſcintillating ſtream. 340
So, borne on brazen talons, watch'd of old
The ſleepleſs dragon o'er his fruits of gold;
Bright beam'd his ſcales, his eye-balls blazed with ire,
And his wide noſtrils breath'd inchanted fire.

" *You* bid gold-leaves, in cryſtal lantherns held,
Approach attracted, and recede repel'd; 346
While paper-nymphs inſtinct with motion riſe,
And dancing fauns the admiring Sage ſurprize.
*Or*, if on wax ſome fearleſs Beauty ſtand,
And touch the ſparkling rod with graceful hand; 350
Through her fine limbs the mimic lightnings dart,
And flames innocuous eddy round her heart;
O'er her fair brow the kindling luſtres glare,
Blue rays diverging from the briſtling hair;

bodies, as when a nail is hammered or filed till it becomes hot, as mentioned in additional Notes, No. VII. Some Philoſophers have endeavoured to account for this phenomenon by ſuppoſing the exiſtence of two electric fluids which may be called the vitreous and reſinous ones, inſtead of the plus and minus of the ſame ether. But its accumulation on the rubbed glaſs bears great analogy to its accumulation on the ſurface of the Leyden bottle, and cannot perhaps be explained from any known mechanical or chemical principle. See note on Gymnotus. l. 202, of this Canto.

*Cold from each point.* l. 339. See additional note, No. XIII.

*You bid gold leaves.* l. 345. Alluding to the very ſenſible electrometer improved by Mr. Bennett, it conſiſts of two ſlips of gold-leaf ſuſpended from a tin cap in a glaſs cylinder, which has a partial coating without, communicating with the wooden pedeſtal. If a ſtick of ſealing wax be rubbed for a moment on a dry cloth, and then held in the air *at the diſtance of two or three feet* from the cap of this inſtrument, the gold leaves ſeparate, ſuch is its aſtoniſhing ſenſibility to electric influence! (See Bennet on electricity, Johnſon, Lond.) The nerves of ſenſe of animal bodies do not ſeem to be affected by leſs quantities of light or heat!

While ſome fond youth the kiſs ethereal ſips.
And ſoft fires iſſue from their meeting lips.
So round the virgin Saint in ſilver ſtreams
The holy Halo ſhoots it's arrowy beams.

"*You* crowd in coated jars the denſer fire,
Pierce the thin glaſs, and fuſe the blazing wire;
Or dart the red flaſh through the circling band
Of youths and timorous damſels, hand in hand.
—Starts the quick Ether through the fibre-trains
Of dancing arteries, and of tingling veins,
Goads each fine nerve, with new ſenſation thrill'd,
Bends the reluctant limbs with power unwill'd;

*The holy Halo.* l. 358. I believe it is not known with certainty at what time the painters firſt introduced the luminous circle round the head to import a Saint or holy perſon. It is now become a part of the ſymbolic language of painting, and it is much to be wiſhed that this kind of hyeroglyphic character was more frequent in that art; as it is much wanted to render hiſtoric pictures both more intelligible, and more ſublime; and why ſhould not painting as well as poetry expreſs itſelf in metaphor, or in indiſtinct allegory? A truly great modern painter lately endeavoured to enlarge the ſphere of pictorial language, by putting a demon behind the pillow of a wicked man on his death bed. Which unfortunately for the ſcientific part of painting, the cold criticiſm of the preſent day has depreciated; and thus barred perhaps the only road to the further improvement in this ſcience.

*With new ſenſation thrill'd.* l. 365. There is probably a ſyſtem of nerves in animal bodies for the purpoſe of perceiving heat; ſince the degree of this fluid is ſo neceſſary to health that we become preſently injured either by its acceſs or defect; and becauſe almoſt every part of our bodies is ſupplied with branches from different pairs of nerves, which would not ſeem neceſſary for their motion alone. It is therefore probable, that our ſenſation of electricity is only of its violence in paſſing through our ſyſtem by its ſuddenly diſtending the muſcles, like any other mechanical violence; and that it is general pain alone that we feel, and not any ſenſation analogous to the ſpecific quality of the object. Nature may ſeem to have been niggardly to mankind in beſtowing upon them ſo few ſenſes; ſince a ſenſe to have perceived electricity, and another to have perceived magnetiſm might have been of great ſervice to them, many ages before

Palſy's cold hands the fierce concuſſion own,
And Life clings trembling on her tottering throne.—
So from dark clouds the playful lightning ſprings,
Rives the firm oak, or prints the Fairy-rings.

2. *Nymphs!* on that day *Ye* ſhed from lucid eyes
Celeſtial tears, and breathed ethereal ſighs!
When RICHMAN rear'd, by fearleſs haſte betray'd,
The wiry rod in Nieva's fatal ſhade;—
Clouds o'er the Sage, with fringed ſkirts ſucceed,
Flaſh follows flaſh, the warning corks recede;
Near and more near He ey'd with fond amaze
The ſilver ſtreams, and watch'd the ſaphire blaze;
Then burſts the ſteel, the dart electric ſped,
And the bold Sage lay number'd with the dead!

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theſe fluids were diſcovered by accidental experiment, but it is poſſible an increaſed number of ſenſes might have incommoded us by adding to the ſize of our bodies.

*Palſy's cold hands.* l. 367. Paralytic limbs are in general only incapable of being ſtimulated into action by the power of the will; ſince the pulſe continues to beat and the fluids to be abſorbed in them; and it commonly happens, when paralytic people yawn and ſtretch themſelves, (which is not a voluntary motion,) that the affected limb moves at the ſame time. The temporary motion of a paralytic limb is likewiſe cauſed by paſſing the electric ſhock through it; which would ſeem to indicate ſome analogy between the electric fluid, and the nervous fluid, which is ſeparated from the blood by the brain, and thence diffuſed along the nerves for the purpoſe of motion and ſenſation. It probably deſtroys life by its ſudden expanſion of the nerves or fibres of the brain; in the ſame manner as it fuſes metals and ſplinters wood or ſtone, and removes the atmoſphere, when it paſſes from one object to another in a denſe ſtate.

*Prints the Fairy rings.* l. 370. See additional note No. XIII.

*When Richman reared.* l. 373. Dr. Richman profeſſor of natural Philoſophy at Peterſburgh about the year 1763, elevated an inſulated metallic rod to collect the aerial electricity, as Dr. Franklin had previouſly done at Philadelphia; and as he was obſerving the repulſion of the balls of his electrometer approached too near the conductor, and receiving

*Nymphs !* on that day *Ye* ſhed from lucid eyes
Celeſtial tears, and breathed ethereal ſighs !

3. “ *You* led your FRANKLIN to your glazed retreats,
Your air-built caſtles, and your ſilken ſeats ;
Bade his bold arm invade the lowering ſky,
And ſeize the tip-toe lightnings, ere they fly ;
O’er the young Sage your myſtic mantle ſpread,
And wreath’d the crown electric round his head.—
Thus when on wanton wing intrepid *Love*
Snatch’d the raiſed lightning from the arm of JOVE ;

the lightening in his head with a loud exploſion, was ſtruck dead amidſt his family.

*You led your Franklin.* l. 383. Dr. Franklin was the firſt that diſcovered that lightening conſiſted of electric matter, he elevated a tall rod with a wire wrapped round it, and fixing the bottom of a rod into a glaſs bottle, and preſerving it from falling by means of ſilk-ſtrings, he found it electrified whenever a cloud paſſed over it, receiving ſparks by his finger from it, and charging coated phials. This great diſcovery taught us to defend houſes and ſhips and temples from lightening, and alſo to underſtand *that people are always perfectly ſafe in a room during a thunder ſtorm if they keep themſelves at three or four feet diſtance from the walls ;* for the matter of lightening in paſſing from the clouds to the earth, or from the earth to the clouds, runs through the walls of a houſe, the trunk of a tree, or other elevated object ; except there be ſome moiſter body, as an animal in contact with them, or nearly ſo ; and in that caſe the lightening leaves the wall or tree, and paſſes through the animal ; but as it can paſs through metals with ſtill greater facility, it will leave animal bodies to paſs through metallic ones.

If a perſon in the open air be ſurpriſed by a thunderſtorm, he will know his danger by obſerving on a ſecond watch the time which paſſes between the flaſh and crack, and reckoning a mile for every four ſeconds and a half, and a little more. For ſound travels at the rate of 1142 feet in a ſecond of time, and the velocity of light through ſuch ſmall diſtances is not to be eſtimated. In theſe circumſtances a perſon will be ſafer by laying down on the ground, than erect, and ſtill ſafer if within a few feet of his horſe ; which being then a more elevated animal will receive the ſhock in preference as the cloud paſſes over. See additional notes, No. XIII.

*Intrepid Love.* l. 389. This allegory is uncommonly beautiful, repreſenting Divine Juſtice as diſarmed by Divine Love, and relenting of his

Quick o'er his knee the triple bolt He bent,
The cluſter'd darts and forky arrows rent,
Snapt with illumin'd hands each flaming ſhaft,
His tingling fingers ſhook, and ſtamp'd, and laugh'd;
Bright o'er the floor the ſcatter'd fragments blaz'd, 395
And Gods retreating trembled as they gaz'd;
The immortal Sire, indulgent to his child,
Bow'd his ambroſial locks, and Heaven relenting ſmiled.

VIII. "When Air's pure eſſence joins the vital flood,
And with phoſphoric Acid dyes the blood, 400
*Your Virgin trains* the tranſient *Heat* diſpart,
And lead the ſoft combuſtion round the heart;
Life's holy lamp with fires ſucceſſive feed,
From the crown'd forehead to the proſtrate weed,
From Earth's proud realms to all that ſwim or ſweep
The yielding ether or tumultuous deep. 406
*You* ſwell the bulb beneath the heaving lawn,
Brood the live ſeed, unfold the burſting ſpawn;
Nurſe with ſoft lap, and warm with fragrant breath
The embryon panting in the arms of Death; 410

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purpoſe. It is expreſſed on an agate in the Great Duke's collection at Florence. Spence.

*Tranſient heat diſpart.* l. 401. Dr. Crawford in his ingenious work on animal heat has endeavoured to prove, that during the combination of the pure part of the atmoſphere with the phlogiſtic part of the blood, that much of the matter of the heat is given out from the air; and that this is the great and perpetual ſource of the heat of animals; to which we may add that the phoſphoric acid is probably produced by this combination; by which acid the colour of the blood is changed in the lungs from a deep crimſon to a bright ſcarlet. There ſeems to be however another ſource of animal heat, though of a ſimilar nature; and that is from the chemical combinations produced in all the glands; ſince by whatever cauſe any glandular ſecretion is increaſed, as by friction or topical inflammation, the heat of that part becomes increaſed at the ſame time; thus after the hands have been for a time immerſed in ſnow, on

Youth's vivid eye with living light adorn,
And fire the riſing bluſh of Beauty's golden morn.

“ Thus when the Egg of Night, on Chaos hurl'd,
Burſt, and diſcloſed the cradle of the world ;
Firſt from the gaping ſhell refulgent ſprung
*Immortal Love*, his bow celeſtial ſtrung ;—
O'er the wide waſte his gaudy wings unfold,
Beam his ſoft ſmiles, and wave his curls of gold ;
With ſilver darts He pierced the kindling frame,
And lit with torch divine the ever-living flame.”

IX. *The Goddeſs* pauſed, admired with conſcious pride
The effulgent legions marſhal'd by her ſide,
Forms ſphered in fire with trembling light array'd,
Ens without weight, and ſubſtance without ſhade ;
And while tumultuous joy her boſom warms,
Waves her white hand, and calls her hoſts to arms,

“ Unite, *illuſtrious Nymphs !* your radiant powers,
Call from their long repoſe the *Vernal Hours*.

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coming into a warm room, they become red and hot, without any increaſed pulmonary action. BESIDES THIS there would ſeem to be another material received from the air by reſpiration ; which is ſo neceſſary to life, that the embryon muſt learn to breathe almoſt within a minute after its birth, or it dies. The perpetual neceſſity of breathing ſhews, that the material thus acquired is perpetually conſuming or eſcaping, and on that account require perpetual renovation. Perhaps the ſpirit of animation itſelf is thus acquired from the atmoſphere, which if it be ſuppoſed to be finer or more ſubtle than the electric matter, could not long be retained in our bodies, and muſt therefore require perpetual renovation.

*Thus when the egg of Night.* l. 413. There were two Cupids belonging to the antient mythology, one much elder than the other. The elder cupid, or Eros, or divine Love, was the firſt that came out of the great egg of night, which floated in Chaos, and was broken by the horns of the celeſtial bull, that is, was hatched by the warmth of the ſpring. He

Wake with ſoft touch, with roſy hands unbind
The ſtruggling pinions of the *weſtern Wind*: 430
Chaſe his wan cheeks, his ruffled plumes repair,
And wring the rain-drops from his tangled hair.
Blaze round each froſted rill, or ſtagnant wave,
And charm the NAIAD from her ſilent cave;

was winged and armed, and by his arrows and torch pierced and vivified all things, producing life and joy. Bacon, Vol. V. p. 197. Quarto edit. Lond. 1778. "At this time, (ſays Ariſtophanes,) ſable-winged night "produced an egg, from whence ſprung up like a bloſſom Eros, the "lovely, the deſirable, with his gloſſy golden wings." Avibus. Bryant's Mythology, Vol. II. p. 350. ſecond edition. This intereſting moment of this ſublime allegory Mrs. Coſway has choſen for her very beautiful painting. She has repreſented Eros or divine Love with large wings having the ſtrength of the eagle's wings, and the ſplendor of the peacock's, with his hair floating in the form of flame, and with a halo of light vapour round his head; which illuminates the painting; while he is in the act of ſpringing forwards, and with his hands ſeparating the elements.

*Of the Weſtern Wind.* l. 430. The principal froſts of this country are accompanied or produced by a N. E. wind, and the thaws by a S. W. wind; the reaſon of which is that the N. E. winds conſiſt of regions of air brought from the north, which appear to acquire an eaſterly direction as they advance; and the S. W. winds conſiſt of regions of air brought from the ſouth, which appear to acquire a weſterly direction as they advance. The ſurface of the earth nearer the pole moves ſlower than it does in our latitude; whence the regions of air brought from thence, move ſlower, when they arrive hither, than the earth's ſurface with which they now become in contact; that is they acquire an apparent eaſterly direction, as the earth moves from weſt to eaſt faſter than this new part of its atmoſphere. The S. W. winds on the contrary conſiſt of regions of air brought from the ſouth, where the ſurface of the earth moves faſter than in our latitude; and have therefore a weſterly direction when they arrive hither by their moving faſter than the ſurface of the earth, with which they are in contact; and in general the nearer to the weſt and the greater the velocity of theſe winds the warmer they ſhould be in reſpect to the ſeaſon of the year, ſince they have been brought more expeditiouſly from the ſouth, than thoſe winds which have leſs weſterly direction, and have thence been leſs cooled in their paſſage.

Where, ſhrined in ice, like Niobe ſhe mourns, 435
And claſps with hoary arms her empty urns.
Call your bright myriads, trooping from afar,
With beamy helms, and glittering ſhafts of war;
In phalanx firm the *Fiend of Froſt* aſſail,
Break his white towers, and pierce his cryſtal mail; 440
To Zembla's moon-bright coaſts the Tyrant bear,
And chain him howling to the Northern Bear.

Sometimes I have obſerved the thaw to commence immediately on the change of the wind, even within an hour, if I am not miſtaken, or ſooner. At other times the S. W. wind has continued a day, or even two, before the thaw has commenced; during which time ſome of the froſty air, which had gone ſouthwards, is driven back over us; and in conſequence has taken a weſterly direction, as well as a ſouthern one. At other times I have obſerved a froſt with a N. E. wind every morning, and a thaw with a S. W. wind every noon for ſeveral days together. See additional note, XXXIII.

*The Fiend of Froſt.* l. 439. The principal injury done to vegetation by froſt is from the expanſion of the water contained in the veſſels of plants. Water converted into ice occupies a greater ſpace than it did before, as appears by the burſting of bottles filled with water at the time of their freezing. Hence froſt deſtroys thoſe plants of our iſland firſt, which are moſt ſucculent; and the moſt ſucculent parts firſt of other plants; as their leaves and laſt year's ſhoots; the veſſels of which are diſtended and burſt by the expanſion of their freezing fluids, while the drier or more reſinous plants, as pines, yews, laurels, and other ever-greens, are leſs liable to injury from cold. The trees in vallies are on this account more injured by the vernal froſts than thoſe on eminencies, becauſe their early ſucculent ſhoots come out ſooner. Hence fruit trees covered by a ſix-inch coping of a wall are leſs injured by the vernal froſts becauſe their being ſhielded from ſhowers and the deſcending night-dews has prevented them from being moiſt at the time of their being frozen: which circumſtance has given occaſion to a vulgar error amongſt gardeners, who ſuppoſe froſt to deſcend.

As the common heat of the earth in this climate is 48 degrees, thoſe tender trees which will bear bending down, are eaſily ſecured from the froſt by ſpreading them upon the ground, and covering them with ſtraw or fern. This particularly ſuits fig-trees, as they eaſily bear bending to the ground, and are furniſhed with an acrid juice, which ſecures them from the depredations of inſects; but are nevertheleſs liable to be eaten by mice. See additional notes, No. XII.

" So when enormous GRAMPUS, iſſuing forth
From the pale regions of the icy North;
Waves his broad tail, and opes his ribbed mouth, 445
And ſeeks on winnowing fin the breezy South;
From towns deſerted ruſh the breathleſs hoſts,
Swarm round the hills, and darken all the coaſts;
Boats follow boats along the ſhouting tides,
And ſpears and javelins pierce his blubbery ſides; 450
Now the bold Sailor, raiſed on pointed toe,
Whirls the wing'd harpoon on the ſlimy foe;
Quick ſinks the monſter in his oozy bed,
The blood-ſtain'd ſurges circling o'er his head,
Steers to the frozen pole his wonted track, 455
And bears the iron tempeſt on his back.

X. " On wings of flame, *ethereal Virgins*! ſweep
O'er Earth's fair boſom, and complacent deep;
Where dwell my vegetative realms benumb'd,
In buds impriſon'd, or in bulbs intomb'd, 460

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*In buds impriſon'd.* l. 460. The buds and bulbs of plants conſtitute what is termed by Linneus the Hybernaculum, or winter cradle of the embryon vegetable. The buds ariſe from the bark on the branches of trees, and the bulbs from the caudex of bulbous-rooted plants, or the part from which the fibres of the root are produced, they are defended from too much moiſture, and from froſts, and from the depredations of inſects by various contrivances, as by ſcales, hairs, reſinous varniſhes, and by acrid rinds.

The buds of trees are of two kinds, either flower-buds or leaf buds; the former of theſe produce their ſeeds and die; the latter produce other leaf buds or flower buds and die. So that all the buds of trees may be conſidered as annual plants, having their embryon produced during the preceding ſummer. The ſame ſeems to happen with reſpect to bulbs; thus a tulip produces annually one flower-bearing bulb, ſometimes two, and ſeveral leaf-bearing bulbs; and then the old root periſhes. Next year the flower-bearing bulb produces ſeeds and other bulbs and periſhes; while the leaf-bearing bulb, producing other bulbs only, periſhes likewiſe; theſe circumſtances eſtabliſh a ſtrict analogy between bulbs and buds. See additional notes, No. XIV.

Pervade, *pellucid Forms*! their cold retreat,
Ray ſrom bright urns your viewleſs floods of *heat*;
From earth's deep waſtes *electric* torrents pour,
Or ſhed from heaven the ſcintillating ſhower;

*Viewleſs floods of heat.* l. 462. The fluid matter of heat, or Calorique, in which all bodies are immerſed, is as neceſſary to vegetable as to animal exiſtence. It is not yet determinable whether heat and light be different materials, or modifications of the ſame materials, as they have ſome properties in common. They appear to be both of them equally neceſſary to vegetable health, ſince without light green vegetables become firſt yellow, that is, they loſe the blue colour, which contributed to produce the green; and afterwards they alſo loſe the yellow and become white; as is ſeen in cellery blanched or etiolated for the table by excluding the light from it.

The upper ſurface of leaves, which I ſuppoſe to be their organ of reſpiration, ſeems to require light as well as air; ſince plants which grow in windows on the inſide of houſes are equally ſollicitous to turn the upper ſide of their leaves to the light. Vegetables at the ſame time exſude or perſpire a great quantity from their leaves, as animals do from their lungs; this perſpirable matter as it riſes from their fine veſſels, (perhaps much finer than the pores of animal ſkins,) is divided into inconceivable tenuity; and when acted upon by the Sun's light appears to be decompoſed; the hydrogene becomes a part of the vegetable, compoſing oils or reſins; and the Oxygene combined with light or calorique aſcends, producing the pure part of the atmoſphere or vital air. Hence during the light of the day vegetables give up more pure air than their reſpiration injures; but not ſo in the night, even though equally expoſed to warmth. This ſingle fact would ſeem to ſhew, that light is eſſentially different from heat; and it is perhaps by its combination with bodies, that their combined or latent heat is ſet at liberty, and becomes ſenſible. See additional note, XXXIV.

*Electric torrents pour.* l. 463. The influence of electricity in forwarding the germination of plants and their growth ſeems to be pretty well eſtabliſhed; though Mr. Ingenhouz did not ſucceed in his experiments, and thence doubts the ſucceſs of thoſe of others. And though M. Rouland from his new experiments believes, that neither poſitive nor negative electricity increaſes vegetation; both which philoſophers had previouſly been ſupporters of the contrary doctrine; for many other naturaliſts have ſince repeated their experiments relative to this object, and their new reſults have confirmed their former ones. Mr. D'Ormoy and the two Roziers have found the ſame ſucceſs in numerous experiments which they have made in the laſt two years; and Mr. Carmoy has ſhewn in a convincing manner that electricity accelerates germination.

Pierce the dull root, relax its fibre-trains,
Thaw the thick blood, which lingers in its veins;
Melt with warm breath the fragrant gums, that bind
The expanding foliage in its ſcaly rind;
And as in air the laughing leaflets play,
And turn their ſhining boſoms to the ray,
NYMPHS! with ſweet ſmile each opening flower invite,
And on its damaſk eyelids pour the *light*.

"So ſhall my pines, Canadian wilds that ſhade,
Where no bold ſtep has pierc'd the tangled glade,
High-towering palms, that part the Southern flood
With ſhadowy iſles and continents of wood.
Oaks, whoſe broad antlers creſt Britannia's plain,
Or bear her thunders o'er the conquer'd main,

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Mr. D'Ormoy not only found various ſeeds to vegetate ſooner, and to grow taller which were put upon his inſulated table and ſupplied with electricity, but alſo that ſilk-worms began to ſpin much ſooner which were kept electrified than thoſe of the ſame hatch which were kept in the ſame place and manner, except that they were not electrified. Theſe experiments of M. D'Ormoy are detailed at length in the Journal de Phyſique of Rozier, Tom. XXXV. p. 270.

M. Bartholon, who had before written a tract on this ſubject, and propoſed ingenious methods for applying electricity to agriculture and gardening, has alſo repeated a numerous ſet of experiments; and ſhews both that natural electricity, as well as the artificial, increaſes the growth of plants, and the germination of ſeeds; and oppoſes Mr. Ingenhouz by very numerous and concluſive facts. Ib. Tom. XXXV. p. 401.

Since by the late diſcoveries or opinions of the Chemiſts there is reaſon to believe that water is decompoſed in the veſſels of vegetables; and that the Hydrogene or inflammable air, of which it in part conſiſts, contributes to the nouriſhment of the plant, and to the production of its oils, roſins, gums, ſugar, &c. and laſtly as electricity decompoſes water into theſe two airs termed Oxygene and Hydrogene, there is a powerful analogy to induce us to believe that it accelerates or contributes to the growth of vegetation, and like heat may poſſibly enter into combination with many bodies, or form the baſis of ſome yet unanaliſed acid.

Shout, as you paſs, inhale the genial ſkies,
And baſk and brighten in your beamy eyes;
Bow their white heads, admire the changing clime;
Shake from their candied trunks the tinkling rime;
With burſting buds their wrinkled barks adorn,
And wed the timorous floret to her thorn;
Deep ſtrike their roots, their lengthening tops revive,
And all my world of foliage wave, alive.

"Thus with Hermetic art the ADEPT combines
The royal acid with cobaltic mines;
Marks with quick pen, in lines unſeen portrayed,
The bluſhing mead, green dell, and duſky glade;
Shades with pellucid clouds the tintleſs field,
And all the future Group exiſts conceal'd;
Till waked by fire the dawning tablet glows,
Green ſprings the herb, the purple floret blows,
Hills vales and woods in bright ſucceſſion riſe,
And all the living landſcape charms his eyes.

*Thus with Hermetic art.* l. 487. The ſympathetic inks made by Zaffre diſſolved in the marine and nitrous acids have this curious property, that being brought to the fire one of them becomes green, and the other red; but what is more wonderful, they again loſe theſe colours, (unleſs the heat has been too great,) on their being again withdrawn from the fire. Fire-ſcreens have been thus painted, which in the cold have ſhewn only the trunk and branches of a dead tree, and ſandy hills, which on their approach to the fire have put forth green leaves and red flowers, and graſs upon the mountains. The proceſs of making theſe inks is very eaſy; take Zaffre, as ſold by the druggiſts, and digeſt it in aqua regia, and the calx of Cobalt will be diſſolved; which ſolution muſt be diluted with a little common water to prevent it from making too ſtrong an impreſſion on the paper; the colour when the paper is heated becomes of a fine green-blue. If Zaffre or Regulus of Cobalt be diſſolved in the ſame manner in ſpirit of nitre, or acqua fortis, a reddiſh colour is produced on expoſing the paper to heat. Chemical Dictionary by Mr. Keir, Art. Ink Sympathetic.

IX. " With creſt of gold ſhould ſultry SIRIUS glare,
And with his kindling treſſes ſcorch the air ;
With points of flame the ſhafts of Summer arm,
And burn the beauties he deſigns to warm ;—
—So erſt when JOVE his oath extorted mourn'd,
And clad in glory to the Fair return'd ;
While Loves at forky bolts their torches light,
And reſting lightnings gild the car of Night :
His blazing form the dazzled Maid admir'd,
Met with fond lips, and in his arms expir'd ;—
*Nymphs!* on light pinion lead your banner'd hoſts
High o'er the cliffs of ORKNEY's gulphy coaſts ;
Leave on your left the red volcanic light,
Which HECCLA lifts amid the duſky night ;
Mark on the right the *Dofrine's* ſnow-capt brow,
Where whirling *Maelſtrome* roars and foams below ;
Watch with unmoving eye, where CEPHEUS bends
His triple crown, his ſcepter'd hand extends ;
Where ſtuds CASSIOPE with ſtars unknown
Her golden chair, and gems her ſapphire zone ;
Where with vaſt convolution DRACO holds
The ecliptic axis in his ſcaly folds,
O'er half the ſkies his neck enormous rears,
And with immenſe meanders parts the BEARS ;
Onward, the kindred BEARS with footſtep rude
Dance round the pole, purſuing and purſued.

" There in her azure coif and ſtarry ſtole,
Grey *Twilight* ſits, and rules the ſlumbering Pole ;

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*With ſtars unknown.* l. 515. Alluding to the ſtar which appeared in the chair of Caſſiopea in the year 1572, which at firſt ſurpaſſed Jupiter in magnitude and brightneſs, diminiſhed by degrees and diſappeared in 18 months; it alarmed all the aſtronomers of the age, and was eſteemed a comet by ſome.—Could this have been the Georgium Sidus?

Bends the pale moon-beams round the ſparkling coaſt,
And ſtrews with livid hands eternal froſt. 526
There, *Nymphs!* alight, array your dazzling powers,
With ſudden march alarm the torpid Hours;
On ice-built iſles expand a thouſand ſails,
Hinge the ſtrong helms, and catch the frozen gales; 530

*On ice-built iſles.* l. 529. There are many reaſons to believe from the accounts of travellers and navigators, that the iſlands of ice in the higher northern latitudes as well as the Glaciers on the Alps continue perpetually to increaſe in bulk. At certain times in the ice-mountains of Switzerland there happen cracks which have ſhown the great thickneſs of the ice, as ſome of theſe cracks have meaſured three or four hundred ells deep. The great iſlands of ice in the northern ſeas near Hudſon's bay have been obſerved to have been immerſed above one hundred fathoms beneath the ſurface of the ſea, and to have riſen a fifth or ſixth part above the ſurface, and to have meaſured between three and four miles in circumference. Phil. Tranſ. No. 465. Sect. 2.

Dr. Liſter endeavoured to ſhew that the ice of ſea-water contains ſome ſalt and perhaps leſs air than common ice, and that it is therefore much more difficult of ſolution; whence he accounts for the perpetual and great increaſe of theſe floating iſlands of ice. Philoſ. Tranſ. No. 169.

As by a famous experiment of Mr. Boyles it appears that ice evaporates very faſt in ſevere froſty weather when the wind blows upon it; and as ice in a thawing ſtate is known to contain ſix times more cold than water at the ſame degree of ſenſible coldneſs, it is eaſy to underſtand that winds blowing over iſlands and continents of ice perhaps much below nothing on Farenheit's ſcale, and coming from thence into our latitude muſt bring great degrees of cold along with them. If we add to this the quantity of cold produced by the evaporation of the water as well as by the ſolution of the ice, we cannot doubt but that the northern ice is the principle ſource of the coldneſs of our winters, and that it is brought hither by the regions of air blowing from the north, and which take an apparent eaſterly direction by their coming to a part of the ſurface of the earth which moves faſter than the latitude they come from. Hence the increaſe of the ice in the polar regions by increaſing the cold of our climate adds at the ſame time to the bulk of the Glaciers of Italy and Switzerland.

If the nations who inhabit this hemiſphere of the globe, inſtead of deſtroying their ſea-men and exhauſting their wealth in unneceſſary wars, could be induced to unite their labours to navigate theſe immenſe maſſes of ice into the more ſouthern oceans, two great advantages would reſult to mankind, the tropic countries would be much cooled by their ſolution,

The winged rocks to feveriſh climates guide,
Where fainting Zephyrs pant upon the tide;
Paſs, where to CEUTA CALPE's thunder roars,
And anſwering echoes ſhake the kindred ſhores;
Paſs, where with palmy plumes CANARY ſmiles, 535
And in her ſilver girdle binds her iſles;
Onward, where *Niger's* duſky Naiad laves
A thouſand kingdoms with prolific waves,
Or leads o'er golden ſands her threefold train
In ſteamy channels to the fervid main, 540
While ſwarthy nations croud the ſultry coaſt,
Drink the freſh breeze, and hail the floating Froſt,
*Nymphs!* veil'd in miſt, the melting treaſures ſteer,
And cool with arctic ſnows the tropic year.
So from the burning Line by Monſoons driven 545
Clouds ſail in ſquadrons o'er the darken'd heaven;

and our winters in this latitude would be rendered much milder for perhaps a century or two, till the maſſes of ice become again enormous.

Mr. Bradley aſcribes the cold winds and wet weather which ſometimes happen in May and June to the ſolution of ice-iſlands accidentally floating from the north. Treatiſe on Huſbandry and Gardening, Vol. II. p. 437. And adds, that Mr. Barham about the year 1718, in his voyage from Jamaica to England in the beginning of June, met with ice-iſlands coming from the north, which were ſurrounded with ſo great a fog that the ſhip was in danger of ſtriking upon them, and that one of them meaſured ſixty miles in length.

We have lately experienced an inſtance of ice-iſlands brought from the Southern polar regions, on which the Guardian ſtruck at the beginning of her paſſage from the Cape of Good Hope towards Botany Bay, on December 22, 1789. Theſe iſlands were involved in miſt, were about one hundred and fifty fathoms long, and about fifty fathoms above the ſurface of the water. A part from the top of one of them broke off and fell into the ſea, cauſing an extraordinary commotion in the water and a thick ſmoke all round it.

*Threefold train.* l. 539. The river Niger after traverſing an immenſe tract of populous country is ſuppoſed to divide itſelf into three other great rivers. The Rio Grande, the Gambia, and the Senegal. Gold-duſt is obtained from the ſands of theſe rivers.

Wide waſtes of ſand the gelid gales pervade,
And Ocean cools beneath the moving ſhade.

XII. Should Solstice, ſtalking through the ſickening bowers,
Suck the warm dew-drops, lap the falling ſhowers;
Kneel with parch'd lip, and bending from it's brink
From dripping palm the ſcanty river drink;
*Nymphs!* o'er the ſoil ten thouſand points erect,
And high in air the electric flame collect.
Soon ſhall dark miſts with ſelf-attraction ſhroud
The blazing day, and ſail in wilds of cloud;

*Wide waſtes of ſand.* l. 547. When the ſun is in the Southern tropic 36 deg. diſtant from the zenith, the thermometer is ſeldom lower than 72 deg. at Gondar in Abyſſinia, but it falls to 60 or 53 deg. when the ſun is immediately vertical; ſo much does the approach of rain counteract the heat of the ſun. Bruce's Travels, Vol. 3. p. 670.

*Ten thouſand points erect.* l. 553. The ſolution of water in air or in calorique, ſeems to acquire electric matter at the ſame time, as appears from an experiment of Mr. Bennet. He put ſome live coals into an inſulated funnel of metal, and throwing on them a little water obſerved that the aſcending ſteam was electriſed plus, and the water which deſcended through the funnel was electriſed minus. Hence it appears that though clouds by their change of form may ſometimes become electriſed minus yet they have in general an accumulation of electricity. This accumulation of electric matter alſo evidently contributes to ſupport the atmoſpheric vapour when it is condenſed into the form of clouds, becauſe it is ſeen to deſcend rapidly after the flaſhes of lightning have diminiſhed its quantity; whence there is reaſon to conclude that very numerous metallic rods with fine points erected high in the air might induce it at any time to part with ſome of its water.

If we may truſt the theory of Mr. Lavoiſier concerning the compoſition and decompoſition of water, there would ſeem another ſource of thunder-ſhowers; and that is, that the two gaſſes termed oxygene gas or vital air, and hydrogene gas or inflammable air, may exiſt in the ſummer atmoſphere in a ſtate of mixture but not of combination, and that the electric ſpark or flaſh of lightning may combine them and produce water inſtantaneouſly.

Each ſilvery Flower the ſtreams aerial quaff,
Bow her ſweet head, and infant Harveſt laugh.

“ Thus when Elija mark'd from Carmel's brow
In bright expanſe the briny flood below;
Roll'd his red eyes amid the ſcorching air,
Smote his firm breaſt, and breathed his ardent prayer;
High in the midſt a maſſy altar ſtood,
And ſlaughter'd offerings preſs'd the piles of wood;
While Israel's chief the ſacred hill ſurround,
And famiſh'd armies crowd the duſty ground;
While proud Idolatry was leagued with dearth,
And wither'd famine ſwept the deſert earth.—
“ *Oh, mighty* Lord! thy woe-worn ſervant hear,
“ Who calls thy name in agony of prayer;
“ Thy fanes diſhonour'd, and thy prophets ſlain,
“ Lo! I alone ſurvive of all thy train!—
“ Oh ſend from heaven thy ſacred fire,—and pour
“ O'er the parch'd land the ſalutary ſhower,—
“ So ſhall thy Prieſt thy erring flock recal,—
“ And ſpeak in thunder, “ *Thou art Lord of all.*”—
He cried, and kneeling on the mountain-ſands,
Stretch'd high in air his ſupplicating hands.
—Deſcending flames the duſky ſhrine illume;
Fire the wet wood, the ſacred bull conſume;
Wing'd from the ſea the gathering miſts ariſe,
And floating waters darken all the ſkies;
The King with ſhifted reins his chariot bends,
And wide o'er earth the airy flood deſcends:
With mingling cries diſperſing hoſts applaud,
And ſhouting nations own the THE LIVING GOD.”
The *Goddeſs* ceaſed,—the exulting tribes obey,
Start from the ſoil, and win their airy way;
The vaulted ſkies with ſtreams of tranſient rays

Shine, as they paſs, and earth and ocean blaze. 590
So from fierce wars when lawleſs Monarchs ceaſe,
Or Liberty returns with laurel'd Peace;
Bright fly the ſparks, the colour'd luſtres burn,
Flaſh follows flaſh, and flame-wing'd circles turn;
Blue ſerpents ſweep along the duſky air, 595
Imp'd by long trains of ſcintillating hair;
Red rockets riſe, loud cracks are heard on high,
And ſhowers of ſtars ruſh headlong from the ſky,
Burſt, as in ſilver lines they hiſs along,
And the quick flaſh unfolds the gazing throng. 600

# ARGUMENT

## OF THE

## SECOND CANTO.

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# THE

# ECONOMY

# OF

# VEGETATION.

## CANTO II.

AND *now the Goddeſs* with attention ſweet
Turns to the *Gnomes*, that circle round her feet;
Orb within orb approach the marſhal'd trains,
And pigmy legions darken all the plains;
Thrice ſhout with ſilver tones the applauding bands, 5
Bow, ere She ſpeaks, and clap their fairy hands.
So the tall graſs, when noon-tide zephyr blows,
Bends its green blades in undulating rows;
Wide o'er the fields the billowy tumult ſpreads,
And ruſtling harveſts bow their golden heads. 10

I. "*Gnomes! your* bright forms, preſiding at her birth,
Clung in fond ſquadrons round the new-born *Earth*;

When high in ether, with exploſion dire,
From the deep craters of his realms of fire,
The whirling Sun this ponderous planet hurl'd,
And gave the aſtoniſh'd void another world.
When from its vaporous air, condenſed by cold,
Deſcending torrents into oceans roll'd;
And fierce attraction with relentleſs force
Bent the reluctant wanderer to its courſe.

" Where yet the Bull with diamond-eye adorns
The Spring's fair forehead, and with golden horns;
Where yet the Lion climbs the ethereal plain,
And ſhakes the Summer from his radiant mane;
Where Libra lifts her airy arm, and weighs,
Poiſed in her ſilver ballance, nights and days;
With paler luſtres where Aquarius burns,
And ſhowers the ſtill ſnow from his hoary urns;

*From the deep craters.* l. 14. The exiſtence of ſolar volcanos is countenanced by their analogy to terreſtrial, and lunar volcanos; and by the ſpots on the ſun's diſk, which have been ſhewn by Dr. Wilſon to be excavations through its luminous ſurface, and may be ſuppoſed to be the cavities from whence the planets and comets were ejected by exploſions. See additional notes, No. 15. on ſolar Volcanos.

*When from its vaporous air.* l. 17. If the nucleus of the earth was thrown out from the ſun by an exploſion along with as large a quantity of ſurrounding hot vapour as its attraction would occaſion to accompany it, the ponderous ſemi-fluid nucleus would take a ſpherical form from the attraction of its own parts, which would become an oblate ſpheroid from its diurnal revolution. As the vapour cooled the water would be precipitated, and an ocean would ſurround the ſpherical nucleus with a ſuperincumbent atmoſphere. The nucleus of ſolar lava would likewiſe become harder as it became cooler. To underſtand how the ſtrata of the earth were afterwards formed from the ſediments of this circumfluent ocean the reader is referred to an ingenious Treatiſe on the Theory of the Earth by Mr. Whitehurſt, who was many years a watch-maker and engineer at Derby, but whoſe ingenuity, integrity, and humanity, were rarely equalled in any ſtation of life.

*Your* ardent troops purſued the flying ſphere,
Circling the ſtarry girdle of the year;
While ſweet viciſſitudes of day and clime
Mark'd the new annals of enaſcent Time.

II. "*You* trod with printleſs ſtep Earth's tender globe,
While Ocean wrap'd it in his azure robe;
Beneath his waves her hardening ſtrata ſpread,
Raiſed her *Primeval Iſlands* from his bed,
Stretch'd her wide lawns, and ſunk her winding dells,
And deck'd her ſhores with corals, pearls, and ſhells.

"O'er thoſe bleſt iſles no ice-crown'd mountains tower'd,
No lightnings darted, and no tempeſts lower'd;

*While ocean wrap'd.* l. 34. See additional notes, No. XVI. on the production of calcareous earth.

*Her hardening ſtrata ſpread.* l. 35. The granite, or moor-ſtone, or porphory, conſtitute the oldeſt part of the globe, ſince the limeſtone, ſhells, coralloids, and other ſea productions reſt upon them; and upon theſe ſea-productions are found clay, iron, coal, ſalt, and ſiliceous ſand or grit-ſtone. Thus there ſeem to be three diviſions of the globe diſtinctly marked; the firſt I ſuppoſe to have been the original nucleus of the earth, or lava projected from the ſun; 2. over this lie the recrements of animal and vegetable matter produced in the ocean; and, 3. over theſe the recrements of animal and vegetable matter produced upon the land. Beſides theſe there are bodies which owe their origin to a combination of thoſe already mentioned, as ſiliceous ſand, fluor, alabaſter; which ſeem to have derived their acids originally from the vegetable kingdom, and their earthy baſes from ſea-productions. See additional notes, No. XVI. on calcareous earth.

*Raiſed her primeval iſlands.* l. 36. The nucleus of the earth, ſtill covered with water, received perpetual increaſe by the immenſe quantities of ſhells and coralloids either annually produced and relinquiſhed, or left after the death of the animals. Theſe would gradually by their different degrees of coheſion be ſome of them more and others leſs removable by the influence of ſolar tides, and gentle tropical breezes, which then muſt have probably extended from one pole to the other; for it is ſuppoſed the moon was not yet produced, and that no ſtorms or unequal winds had yet exiſtence.

Soft fell the veſper-drops, condenſed below,
Or bent in air the rain-refracted bow;
Sweet breathed the zephyrs, juſt perceiv'd and loſt:
And brineleſs billows only kiſs'd the coaſt;
Round the bright zodiac danced the vernal hours,
And Peace, the Cherub, dwelt in mortal bowers!

"So young DIONE, nurſed beneath the waves,
And rock'd by Nereids in their coral caves,
Charm'd the blue ſiſterhood with playful wiles,
Liſp'd her ſweet tones, and tried her tender ſmiles.
Then, on her beryl throne by Tritons borne,
Bright roſe the Goddeſs like the Star of morn;
When with ſoft fires the milky dawn He leads,
And wakes to life and love the laughing meads;—

Hence then the primeval iſlands had their gradual origin, were raiſed but a few feet above the level of the ſea, and were not expoſed to the great or ſudden variations of heat and cold, as is ſo well explained in Mr. Whithurſt's Theory of the Earth, chap. xvi. Whence the paradiſe of the ſacred writers, and the golden age of the profane ones, ſeems to have had a real exiſtence. As there can be no rainbow, when the heavens are covered with clouds, becauſe the ſun-beams are then precluded from falling upon the rain-drops oppoſite to the eye of the ſpectator, the rainbow is a mark of gentle or partial ſhowers. Mr. Whitehurſt has endeavoured to ſhow that the primitive iſlands were only moiſtened by nocturnal dews and not by ſhowers, as occurs at this day to the Delta of Egypt; and is thence of opinion, that the rainbow had no exiſtence till after the production of mountains and continents. As the ſalt of the ſea has been gradually accumulating, being waſhed down into it from the recrements of animal and vegetable bodies, the ſea muſt originally have been as freſh as river water; and as it is not yet ſaturated with ſalt, muſt become annually more ſaline. See note on l. 117 of this Canto.

*So young Dione.* l. 47. There is an antient gem repreſenting Venus riſing out of the ocean ſupported by two Tritons. From the formality of the deſign it would appear to be of great antiquity before the introduction of fine taſte into the world. It is probable that this beautiful allegory was originally an hieroglyphic picture (before the invention of letters) deſcriptive of the formation of the earth from the ocean, which ſeems to have been an opinion of many of the moſt antient philoſophers.

With roſy fingers, as uncurl'd they hung
Round her fair brow, her golden locks ſhe wrung;
O'er the ſmooth ſurge on ſilver ſandals ſtood,
And look'd enchantment on the dazzled flood.—
The bright drops, rolling from her lifted arms,
In ſlow meanders wander o'er her charms,
Seek round her ſnowy neck their lucid track,
Pearl her white ſhoulders, gem her ivory back,
Round her fine waiſt and ſwelling boſom ſwim,
And ſtar with glittering brine each cryſtal limb.—
—The immortal form enamour'd Nature hail'd,
And Beauty blazed to heaven and earth, unvail'd.

III. "You! who then, kindling after many an age,
Saw with new fires the firſt Volcano rage,
O'er ſmouldering heaps of livid ſulphur ſwell
At Earth's firm centre, and diſtend her ſhell,

E

*The firſt volcano.* l. 68. As the earth before the exiſtence of earthquakes was nearly level, and the greateſt part of it covered with ſea; when the firſt great fires began deep in the internal parts of it, thoſe parts would become much expanded; this expanſion would be gradually extended, as the heat increaſed, through the whole terraqueous globe of 7000 miles diameter; the cruſt would thence in many places open into fiſſures, which by admitting the ſea to flow in upon the fire, would produce not only a quantity of ſteam beyond calculation by its expanſion, but would alſo by its decompoſition produce inflammable air and vital air in quantities beyond conception, ſufficient to effect thoſe violent exploſions, the veſtiges of which all over the world excite our admiration and our ſtudy; the difficulty of underſtanding how ſubterraneous fires could exiſt without the preſence of air has diſappeared ſince Dr. Prieſtley's diſcoveries of ſuch great quantities of pure air which conſtitute all the acids, and conſequently exiſt in all ſaline bodies, as ſea-ſalt, nitre, lime-ſtone, and in all calciform ores, as manganeſe, calamy, ochre, and other mineral ſubſtances. See an ingenious treatiſe by Mr. Michel on earthquakes in the Philoſ. Tranſ.

In theſe firſt tremendous ignitions of the globe, as the continents were heaved up, the vallies, which now hold the ſea, were formed by the earth ſubſiding into the cavities made by the riſing mountains; as the ſteam, which raiſed them condenſed; which would thence not have any caverns

Saw at each opening cleft the furnace glow,
And ſeas ruſh headlong on the gulphs below.—
*Gnomes*! how you ſhriek'd! when through the troubled air
Roar'd the fierce din of elemental war;
When roſe the continents, and ſunk the main, 75
And Earth's hugh ſphere exploding burſt in twain.—
*Gnomes!* how you gazed! when from her wounded ſide
Where now the South-Sea heaves its waſte of tide,
Roſe on ſwift wheels the Moon's refulgent car,
Circling the ſolar orb, a ſiſter-ſtar, 80
Dimpled with vales, with ſhining hills emboſs'd,
And roll'd round Earth her airleſs realms of froſt.

of great extent remain beneath them, as ſome philoſophers have imagined. The earthquakes of modern days are of very ſmall extent indeed compared to thoſe of antient times, and are ingeniouſly compared by M. De Luc to the operations of a mole-hill, where from a ſmall cavity are raiſed from time to time ſmall quantities of lava or pumice ſtone. Monthly Review, June, 1790.

*The moon's refulgent car*. l. 79. See additional notes, No. XV. on ſolar volcanos.

*Her airleſs realms of froſt*. l. 82. If the moon had no atmoſphere at the time of its elevation from the earth; or if its atmoſphere was afterwards ſtolen from it by the earth's attraction; the water on the moon would riſe quickly into vapour; and the cold produced by a certain quantity of this evaporation would congeal the remainder of it. Hence it is not probable that the moon is at preſent inhabited, but as it ſeems to have ſuffered and to continue to ſuffer much by volcanos, a ſufficient quantity of air may in proceſs of time be generated to produce an atmoſphere; which may prevent its heat from ſo eaſily eſcaping, and its water from ſo eaſily evaporating, and thence become fit for the production of vegetables and animals.

That the moon poſſeſſes little or no atmoſphere is deduced from the undiminiſhed luſtre of the ſtars, at the inſtant when they emerge from behind her diſk. That the ocean of the moon is frozen, is confirmed from there being no appearance of lunar tides; which, if they exiſted, would cover the part of her diſk neareſt the earth. See note on Canto III. l. 61.

"*Gnomes*! how you trembled! with the dreadful force
When Earth recoiling ſtagger'd from her courſe;
When, as her Line in ſlower circles ſpun,
And her ſhock'd axis nodded from the ſun,
With dreadful march the accumulated main
Swept her vaſt wrecks of mountain, vale, and plain;
And, while new tides their ſhouting floods unite,
And hail their Queen, fair Regent of the night;
Chain'd to one centre whirl'd the kindred ſpheres,
And mark'd with lunar cycles ſolar years.

IV. "*Gnomes! you* then bade diſſolving *Shells* diſtil
From the looſe ſummits of each ſhatter'd hill,

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*When earth recoiling.* l. 84. On ſuppoſition that the moon was thrown from the earth by the exploſion of water or the generation of other vapours of greater power, the remaining part of the globe would recede from its orbit in one direction as the moon receded in another, and that in proportion to the reſpective momentum of each, and would afterwards revolve round their common centre of gravity.

If the moon roſe from any part of the earth except exactly at the line or poles, the ſhock would tend to turn the axis of the earth out of its previous direction. And as a maſs of matter riſing from deep parts of the globe would have previouſly acquired leſs diurnal velocity than the earth's ſurface, from whence it roſe, it would receive during the time of its riſing additional velocity from the earth's ſurface, and would conſequently ſo much retard the motion of the earth round its axis.

When the earth thus receded the ſhock would overturn all its buildings and foreſts and the water would ruſh with inconceivable violence over its ſurface towards the new ſatellite, from two cauſes, both by its not at firſt acquiring the velocity with which the earth receded, and by the attraction of the new moon, as it leaves the earth; on theſe accounts at firſt there would be but one tide till the moon receded to a greater diſtance, and the earth moving round a common centre of gravity between them, the water on the ſide furtheſt from the moon would acquire a centrifugal force in reſpect to this common centre between itſelf and the moon.

*Diſſolving ſhells diſtil.* l. 93. The lime-ſtone rocks have had their origin from ſhells formed beneath the ſea, the ſofter ſtrata gradually diſſolving and filling up the interſtices of the harder ones, afterwards when theſe accumulations of ſhells were elevated above the waters the upper ſtrata became diſſolved by the actions of the air and dews, and filled up the

To each fine pore and dark interſtice flow,
And fill with liquid chalk the maſs below.
Whence ſparry forms in duſky caverns gleam
With borrow'd light, and twice refract the beam;
While in white beds congealing rocks beneath
Court the nice chiſſel, and deſire to breathe.—
“ Hence wearied HERCULES in marble rears
His languid limbs, and reſts a thouſand years;
Still, as he leans, ſhall young ANTINOUS pleaſe
With careleſs grace, and unaffected eaſe;
Onward with loftier ſtep APOLLO ſpring,
And launch the unerring arrow from the ſtring;
In Beauty's baſhful form, the veil unfurl'd,
Ideal VENUS win the gazing world.
Hence on ROUBILIAC's tomb ſhall Fame ſublime
Wave her triumphant wings, and conquer Time;
Long with ſoft touch ſhall DAMER's chiſſel charm,
With grace delight us, and with beauty warm,

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interſtices beneath, producing ſolid rocks of different kinds from the coarſe lime-ſtones to the fineſt marbles. When thoſe lime-ſtones have been in ſuch a ſituation that they could form perfect cryſtals they are called ſpars, ſome of which poſſeſs a double refraction, as obſerved by Sir Iſaac Newton. When theſe cryſtals are jumbled together or mixed with ſome colouring impurities it is termed marble, if its texture be equable and firm; if its texture be coarſe and porous yet hard, it is called lime-ſtone; if its texture be very looſe and porous it is termed chalk. In ſome rocks the ſhells remain almoſt unchanged and only covered, or bedded with lime-ſtone, which ſeems to have been diſſolved and ſunk down amongſt them. In others the ſofter ſhells and bones are diſſolved, and only ſharks teeth or harder echini have preſerved their form inveloped in the chalk or lime-ſtone; in ſome marbles the ſolution has been compleat and no veſtiges of ſhell appear, as in the white kind called ſtatuary by the workmen. See addit. notes. No. XVI.

*Hence wearied Hercules.* l. 101. Alluding to the celebrated Hercules of Glyco reſting after his labours; and to the eaſy attitude of Antinous; the lofty ſtep of the Apollo of Belvidere; and the retreating modeſty of the Venus de Medici. Many of the deſigns by Roubiliac in Weſtminſter Abbey are uncommonly poetical; the allegory of Time and Fame con-

Foster's fine form ſhall hearts unborn engage,
And Melbourn's ſmile enchant another age.

V. *Gnomes! you* then taught tranſuding dews to paſs
Through time-fall'n woods, and root-inwove moraſs 116
Age after age; and with filtration fine
Diſpart, from earths and ſulphurs, the ſaline.

1. "*Hence* with diffuſive *Salt* old Ocean ſteeps
His emerald ſhallows, and his ſapphire deeps. 120

tending for the trophy of General Wade, which is here alluded to, is beautifully told; the wings of Fame are ſtill expanded, and her hair ſtill floating in the air; which not only ſhews that ſhe has that moment arrived, but alſo that her force is not yet expended; at the ſame time, that the old figure of Time with his diſordered wings is rather leaning backwards and yielding to her impulſe, and muſt apparently in another inſtant be driven from his attack upon the trophy.

*Foſter's fine form.* l. 113. Alluding to the beautiful ſtatues of Lady Elizabeth Foſter and of Lady Melbourn executed by the ingenious Mrs. Damer.

*Root-inwove moraſs.* l. 116. The great maſs of matter which reſts upon the lime-ſtone ſtrata of the earth, or upon the granite where the lime-ſtone ſtratum has been removed by earthquakes or covered by lava, has had its origin from the recrements of vegetables and of air-breathing animals, as the lime-ſtone had its origin from ſea animals. The whole habitable world was originally covered with woods, till mankind formed themſelves into ſocieties, and ſubdued them by fire and by ſteel. Hence woods in uncultivated countries have grown and fallen through, many ages, whence moraſſes of immenſe extent; and from theſe as the more ſoluble parts were waſhed away firſt, were produced ſea-ſalt, nitre, iron, and variety of acids, which combining with calcareous matter were productive of many foſſil bodies, as flint, ſea-ſand, ſelenite, with the precious ſtones, and perhaps the diamond. See additional notes. No. XVII.

*Hence with diffuſive ſalt.* l. 119. Salts of various kinds are produced from the recrements of animal and vegetable bodies, ſuch as phoſphoric, ammoniacal, marine ſalt, and others; theſe are waſhed from the earth by rains, and carried down our rivers into the ſea; they ſeem all here to decompoſe each other except the marine ſalt, which has therefore from the beginning of the habitable world been perpetually accumulating.

Oft in wide lakes, around their warmer brim
In hollow pyramids the cryſtals ſwim;
Or, fuſed by earth-born fires, in cubic blocks
Shoot their white forms, and harden into rocks. 124

"Thus, cavern'd round in Cracow's mighty mines,
With cryſtal walls a gorgeous city ſhines;
Scoop'd in the briny rock long ſtreets extend
Their hoary courſe, and glittering domes aſcend;

There is a town in the immenſe ſalt-mines of Cracow in Poland, with a market-place, a river, a church, and a famous ſtatue, (here ſuppoſed to be of Lot's wife) by the moiſt or dry appearance of which the ſubterranean inhabitants are ſaid to know when the weather is fair above ground. The galleries in theſe mines are ſo numerous and ſo intricate, that workmen have frequently loſt their way, their lights having been burnt out, and have periſhed before they could be found. Eſſais, &c. par M. Macquart. And though the arches of theſe different ſtories of galleries are boldly executed, yet they are not dangerous; as they are held together or ſupported by large maſſes of timber of a foot ſquare; and theſe vaſt timbers remain perfectly ſound for many centuries, while all other pillars whether of brick, cement, or ſalt ſoon diſſolve or moulder away. Ibid. Could the timbers over water-mill wheels or cellars, be thus preſerved by occaſionally ſoaking them with brine? Theſe immenſe maſſes of rock-ſalt ſeem to have been produced by the evaporation of ſea-water in the early periods of the world by ſubterranean fires. Dr. Hutton's Theory of the Earth. See alſo Theorie des Sources Salees, par Mr. Struve. Hiſtoire de Sciences de Lauſanne. Tom. II. This idea of Dr. Hutton's is confirmed by a fact mentioned in M. Macquart's Eſſais ſur Minerologie, who found a great quantity of foſſil ſhells, principally bi-valves and madre-pores, in the ſalt-mines of Wialiczka near Cracow. During the evaporation of the lakes of ſalt-water, as in artificial ſalt-works, the ſalt begins to cryſtallize near the edges where the water is ſhalloweſt, forming hollow inverted pyramids; which, when they become of a certain ſize, ſubſide by their gravity; if urged by a ſtronger fire the ſalt fuſes or forms large cubes; whence the ſalt ſhaped in hollow pyramids, called flake-ſalt, is better taſted and preſerves fleſh better, than the baſket or powder ſalt; becauſe it is made by leſs heat and thence contains more of the marine acid. The ſea-water about our iſland contains from about one twenty-eighth to one thirtieth part of ſea-ſalt, and about one eightieth of magneſian ſalt. See Brownrigg on Salt. See note on Ocymum, Vol. II. of this work.

Down the bright ſteeps, emerging into day,
Impetuous fountains burſt their headlong way, 130
O'er milk-white vales in ivory channels ſpread,
And wondering ſeek their ſubterraneous bed.
Form'd in pellucid ſalt with chiſſel nice,
The pale lamp glimmering through the ſculptured ice,
With wild reverted eyes fair LOTTA ſtands, 135
And ſpreads to Heaven, in vain, her glaſſy hands;
Cold dews condenſe upon her pearly breaſt,
And the big tear rolls lucid down her veſt.
Far gleaming o'er the town tranſparent fanes
Rear their white towers, and wave their golden vanes;
Long lines of luſtres pour their trembling rays, 141
And the bright vault returns the mingled blaze.

2. " *Hence* orient *Nitre* owes it's ſparkling birth,
And with priſmatic cryſtals gems the earth,
O'er tottering domes in filmy foliage crawls, 145
Or froſts with branching plumes the mouldering walls.

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*Hence orient Nitre.* l. 143. Nitre is found in Bengal naturally cryſtallized, and is ſwept by brooms from earths and ſtones, and thence called ſweepings of nitre. It has lately been found in large quantities in a natural baſon of calcareous earth at Molfetta in Italy, both in thin ſtrata between the calcareous beds, and in efflorescences of various beautiful leafy and hairy forms. An account of this nitre-bed is given by Mr. Zimmerman and abridged in Rozier's Journal de Phyſique Fevrier. 1790. This acid appears to be produced in all ſituations where animal and vegetable matters are completely decompoſed, and which are expoſed to the action of the air as on the walls of ſtables, and ſlaughter-houſes; the cryſtals are priſms furrowed by longitudinal groves.

Dr. Prieſtley diſcovered that nitrous air or gas which he obtained by diſſolving metals in nitrous acid, would combine rapidly with vital air, and produce with it a true nitrous acid; forming red clouds during the combination; the two airs occupy only the ſpace before occupied by one of them, and at the ſame time heat is given out from the new combination. This diminution of the bulk of a mixture of nitrous gas and vital air, Dr. Prieſtley ingeniouſly uſed as a teſt of the purity of the latter; a diſcovery of the greateſt importance in the analyſis of airs.

As woos Azotic Gas the virgin Air,
And veils in crimſon clouds the yielding Fair,
Indignant Fire, the treacherous courtſhip flies,
Waves his light wing, and mingles with the ſkies.

" So Beauty's *Goddeſs*, warm with new deſire,
Left, on her ſilver wheels, the GOD of Fire;
Her faithleſs charms to fiercer MARS reſign'd.
Met with fond lips, with wanton arms intwin'd.
—Indignant VULCAN eyed the parting Fair,
And watch'd with jealous ſtep the guilty pair;
O'er his broad neck a wiry net he flung,
Quick as he ſtrode, the tinkling meſhes rung;
Fine as the ſpider's flimſy thread He wove
The immortal toil to lime illicit love;
Steel were the knots, and ſteel the twiſted thong,
Ring link'd in ring, indiſſolubly ſtrong;
On viewleſs hooks along the fretted roof
He hung, unſeen, the inextricable woof.—
—Quick ſtart the ſprings, the webs pellucid ſpread,
And lock the embracing Lovers on their bed;

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Mr. Cavendiſh has ſince demonſtrated that two parts of vital air or oxygene, and one part of phlogiſtic air or azote, being long expoſed to electric ſhocks, unite, and produce nitrous acid. Philoſ. Tranſ. Vols. LXXV. and LXXVIII.

Azote is one of the moſt abundant elements in nature, and combined with calorique or heat, it forms azotic gas or phlogiſtic air, and compoſes two thirds of the atmoſphere; and is one of the principal component parts of animal bodies, and when united to vital air or oxygene produces the nitrous acid. Mr. Lavoiſier found that 20½ parts by weight of azote, and 43½ parts of oxygene produced 64 parts of nitrous gas, and by the further addition of 36 parts of oxygene nitrous acid was produced. Traité de Chimie. When two airs become united ſo as to produce an unelaſtic liquid much calorique or heat is of neceſſity expelled from the new combination, though perhaps nitrous acid and oxygenated marine acid admit more heat into their combinations than other acids.

Fierce with loud taunts vindictive VULCAN ſprings,
Tries all the bolts, and tightens all the ſtrings,
Shakes with inceſſant ſhouts the bright abodes,
Claps his rude hands, and calls the feſtive Gods.—
—With ſpreading palms the alarmed Goddeſs tries
To veil her beauties from celeſtial eyes,
Writhes her fair limbs, the ſlender ringlets ſtrains,
And bids her Loves untie the obdurate chains;
Soft ſwells her panting boſom, as ſhe turns,
And her fluſh'd cheek with brighter bluſhes burns.
Majeſtic grief the Queen of Heaven avows,
And chaſte Minerva hides her helmed brows;
Attendant Nymphs with baſhful eyes aſkance
Steal of intangled MARS a tranſient glance;
Surrounding Gods the circling nectar quaff,
Gaze on the Fair, and envy as they laugh.

3. "*Hence* duſky *Iron* ſleeps in dark abodes,
And ferny foliage neſtles in the nodes;

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*Hence duſky Iron.* l. 183. The production of iron from the decompoſition of vegetable bodies is perpetually preſented to our view; the waters oozing from all moraſſes are chalybeate, and depoſit their ochre on being expoſed to the air, the iron acquiring a calciform ſtate from its union with oxygene or vital air. Where thin moraſſes lie on beds of gravel the latter are generally ſtained by the filtration of ſome of the chalybeate water through them. This formation of iron from vegetable recrements is further evinced by the fern leaves and other parts of vegetables, ſo frequently found in the centre of the knobs or nodules of ſome iron-ores.

In ſome of theſe nodules there is a nucleus of whiter iron-earth ſurrounded by many concentric ſtrata of darker and lighter iron-earth alternately. In one, which now lies before me, the nucleus is a priſm of a triangular form with blunted angles, and about half an inch high, and an inch and half broad; on every ſide of this are concentric ſtrata of ſimilar iron-earth alternately browner and leſs brown; each ſtratum is about a tenth of an inch in thickneſs and there are ten of them in number. To what known cauſe can this exactly regular diſtribution of ſo many earthy ſtrata of different colours ſurrounding the nucleus be aſcribed? I don't know that any mineralogiſts have attempted an explanation of this wonderful

Till with wide lungs the panting bellows blow, 185
And waked by fire the glittering torrents flow;
—Quick whirls the wheel, the ponderous hammer falls,
Loud anvils ring amid the trembling walls,
Strokes follow ſtrokes, the ſparkling ingot ſhines,
Flows the red ſlag, the lengthening bar refines; 190
Cold waves, immerſed, the glowing maſs congeal,
And turn to adamant the hiſſing Steel.

phenomenon. I ſuſpect it is owing to the polarity of the central nucleus. If iron-filings be regularly laid on paper by means of a ſmall ſieve, and a magnet be placed underneath, the filings will diſpoſe themſelves in concentric curves with vacant intervals between them. Now if theſe iron-filings are conceived to be ſuſpended in a fluid, whoſe ſpecific gravity is ſimilar to their own, and a magnetic bar was introduced as an axis into this fluid, it is eaſy to foreſee that the iron filings would diſpoſe themſelves into concentric ſpheres, with intervals of the circumnatant fluid between them, exactly as is ſeen in theſe nodules of iron-earth. As all the lavas conſiſt of one fourth of iron, (Kirwan's Mineral) and almoſt all other known bodies, whether of animal or vegetable origin, poſſeſs more or leſs of this property, may not the diſtribution of a great portion of the globe of the earth into ſtrata of greater or leſs regularity be owing to the polarity of the whole?

*And turn to adamant.* l. 192. The circumſtances which render iron more valuable to mankind than any other metal are, 1. its property of being rendered hard to ſo great a degree and thus conſtituting ſuch excellent tools. It was the diſcovery of this property of iron, Mr. Locke thinks, that gave ſuch pre-eminence to the European world over the American one. 2. Its power of being welded; that is, when two pieces are made very hot and applied together by hammering, they unite completely, unleſs any ſcale of iron intervenes; and to prevent this it is uſual for ſmiths to dip the very hot bar in ſand, a little of which fuſes into fluid glaſs with the ſcale and is ſqueezed out from between the uniting parts by the force of hammering. 3. Its power of acquiring magnetiſm.

It is however to be wiſhed that gold or ſilver were diſcovered in as great quantity as iron, ſince theſe metals being indeſtructible by expoſure to air, water, fire or any common acids would ſupply wholeſome veſſels for cookery, ſo much to be deſired, and ſo difficult to obtain, and would form the moſt light and durable coverings for houſes, as well as indeſtructible fire-grates, ovens, and boiling veſſels. See additional notes, No. XVIII. on Steel.

" Laſt MICHELL's hands with touch of potent charm
The poliſh'd rods with powers magnetic arm ;

*Laſt Michell's hands.* l. 193. The diſcovery of the magnet ſeems to have been in very early times; it is mentioned by Plato, Lucretius, Pliny, and Galen, and is ſaid to have taken its name of magnes from Magneſia, a ſea-port of antient Lybia.

As every piece of iron which was made magnetial by the touch of a magnet became itſelf a magnet, many attempts were made to improve theſe artificial magnets, but without much ſucceſs till Servingdon Savary, Eſq; made them of *hardened* ſteel bars, which were ſo powerful that one of them weighing three pounds averdupois would lift another of the ſame weight. Philoſ. Tranſ.

After this Dr. Knight made very ſucceſsful experiments on this ſubject, which, though he kept his method ſecret, ſeems to have excited others to turn their attention to magnetiſm. At this time the Rev. Mr. Michell invented an equally efficacious and more expeditious way of making ſtrong artificial magnets, which he publiſhed in the end of the year 1750, in which he explained his method of what he called " the double touch," and which, ſince Mr. Knight's method has been known, appears to be ſomewhat different from it.

This method of rendering bars of hardened ſteel magnetical conſiſts in holding vertically two or more magnetic bars nearly parallel to each other with their oppoſite poles very near each other, (but nevertheleſs ſeparated to a ſmall diſtance,) theſe are to be ſlided over a line of bars laid horizontally a few times backward and forward. See Michell on Magnetiſm, alſo a detailed account in Chambers's Dictionary.

What Mr. Michell propoſed by this method was to include a very ſmall portion of the horizontal bars, intended to be made magnetical, between the joint forces of two or more bars, already magnetical, and by ſliding them from end to end every part of the line of bars became ſucceſſively included, and thus bars poſſeſſed of a very ſmall degree of magnetiſm to begin with, would in a few times ſliding backwards and forwards make the other ones much more magnetical than themſelves, which are then to be taken up and uſed to touch the former, which are in ſucceſſion to be laid down horizontally in a line.

There is ſtill a great field remains for future diſcoveries in magnetiſm both in reſpect to experiment and theory; the latter conſiſts of vague conjectures the more probable of which are perhaps thoſe of Elpinus, as they aſſimulate it to electricity.

One conjecture I ſhall add, viz. that the polarity of magnetiſm may be owing to the earth's rotatory motion. If heat, electricity, and magnetiſm are ſuppoſed to be fluids of different gravities, heat being the heavieſt of them, electricity the next heavy, and magnetiſm the lighteſt,

With points directed to the polar ſtars
In one long line extend the temper'd bars;
Then thrice and thrice with ſteady eye he guides,
And o'er the adheſive train the magnet ſlides;
The obedient Steel with living inſtinct moves,
And veers for ever to the pole it loves.

"Hail, adamantine *Steel!* magnetic Lord!
King of the prow, the plowſhare, and the ſword!
True to the pole, by thee the pilot guides
His ſteady helm amid the ſtruggling tides,
Braves with broad ſail the immeaſurable ſea,
Cleaves the dark air, and aſks no ſtar but Thee.—
By thee the plowſhare rends the matted plain,
Inhumes in level rows the living grain;
Intruſive foreſts quit the cultured ground,
And Ceres laughs with golden fillets crown'd.—
O'er reſtleſs realms when ſcowling Diſcord flings
Her ſnakes, and loud the din of battle rings;
Expiring Strength, and vanquiſh'd Courage feel
Thy arm reſiſtleſs, adamantine *Steel!*

4. "*Hence* in fine ſtreams diffuſive *Acids* flow,
Or wing'd with fire o'er Earth's fair boſom blow;

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it is evident that by the quick revolution of the earth the heat will be accumulated moſt over the line, electricity next beneath this, and that the magnetiſm will be detruded to the poles and axis of the earth, like the atmoſpheres of common air and of inflammable gas, as explained in the note on Canto I. l. 123.

Electricity and heat will both of them diſplace magnetiſm, and this ſhews that they may gravitate on each other; and hence when too great a quantity of the electric fluid becomes accumulated at the poles by deſcending ſnows, or other unknown cauſes, it may have a tendency to riſe towards the tropics by its centrifugal force, and produce the northern lights. See additional notes, No. I.

*Diffuſive Acids flow.* l. 215. The production of marine acid from decompoſing vegetable and animal matters with vital air, and of nitrous

Tranſmute to glittering Flints her chalky lands,
Or ſink on Ocean's bed in countleſs Sands.
Hence ſilvery Selenite her chryſtal moulds,
And ſoft Aſbeſtus ſmooths his ſilky folds;
His cubic forms phoſphoric Fluor prints,
Or rays in ſpheres his amethyſtine tints.
Soft cobweb clouds tranſparent Onyx ſpreads,
And playful Agates wave their colour'd threads;
Gay pictured Mochoes glow with landſcape-dyes,
And changeful Opals roll their lucid eyes;
Blue lambent light around the Sapphire plays,
Bright Rubies bluſh, and living Diamonds blaze.

acid from azote and vital air, the former of which is united to its baſis by means of the exhalations from vegetable and animal matters, conſtitute an analogy which induces us to believe that many other acids have either their baſes or are united to vital air by means of ſome part of decompoſing vegetable and animal matters.

The great quantities of flint ſand whether formed in mountains or in the ſea would appear to derive its acid from the new world, as it is found above the ſtrata of lime-ſtone and granite which conſtitute the old world, and as the earthy baſis of flint is probably calcareous, a great part of it ſeems to be produced by a conjunction of the new and old world: the recrements of air-breathing animals and vegetables probably afford the acid, and the ſhells of marine animals the earthy baſis, while another part may have derived its calcareous part alſo from the decompoſition of vegetable and animal bodies.

The ſame mode of reaſoning ſeems applicable to the ſiliceous ſtones under various names, as amethyſt, onyx, agate, mochoe, opal, &c. which do not ſeem to have undergone any proceſs from volcanic fires, and as theſe ſtones only differ from flint by a greater or leſs admixture of argillaceous and calcareous earths. The different proportions of which in each kind of ſtone may be ſeen in Mr. Kirwan's valuable Elements of Mineralogy. See additional notes, No. XIX.

*Living diamonds blaze.* l. 228. Sir Iſaac Newton having obſerved the great power of refracting light, which the diamond poſſeſſes above all other cryſtallized or vitreous matter, conjectured that it was an inflammable body in ſome manner congealed. Inſomuch that all the light is reflected which falls on any of its interior ſurfaces at a greater angle of incidence than 24½ degrees; whereas an artificial gem of glaſs does not reflect any light from its hinder ſurface, unleſs that ſurface is inclined in an angle

"Thus, for attractive earth, inconſtant JOVE
Maſk'd in new ſhapes forſook his realms above—
Firſt her ſweet eyes his Eagle-form beguiles,
And HEBE feeds him with ambroſial ſmiles;
Next the chang'd God a Cygnet's down aſſumes,
And playful LEDA ſmooths his gloſſy plumes;
Then glides a ſilver Serpent, treacherous gueſt!
And fair OLYMPIA folds him in her breaſt;
Now lows a milk-white Bull on Afric's ſtrand,
And crops with dancing head the daiſy'd land.—
With roſy wreathes EUROPA's hand adorns
His fringed forehead, and his pearly horns;
Light on his back the ſportive Damſel bounds,
And pleaſed he moves along the flowery grounds;

of 41 degrees. Hence the diamond reflects half as much more light as a factitious gem in ſimilar circumſtances; to which muſt be added its great tranſparency, and the excellent poliſh it is capable of. The diamond had nevertheleſs been placed at the head of cryſtals or precious ſtones by the mineralogiſts, till Bergman ranged it of late in the combuſtible claſs of bodies, becauſe by the focus of Villette's burning mirror it was evaporated by a heat not much greater than will melt ſilver, and gave out light. Mr. Hoepſner however thinks the diſperſion of the diamond by this great heat ſhould be called a phoſphoreſcent evaporation of it, rather than a combuſtion; and from its other analogies of cryſtallization, hardneſs, tranſparency, and place of its nativity, wiſhes again to replace it amongſt the precious ſtones. Obſerv. ſur. la Phyſique, par Rozier, Tom. XXXV. p. 448. See new edition of the Tranſlation of Cronſted, by De Coſta.

*Inconſtant Jove.* l. 229. The purer air or ether in the antient mythology was repreſented by Jupiter, and the inferior air by Juno; and the conjunction of theſe deities was ſaid to produce the vernal ſhowers, and procreate all things, as is further ſpoken of in Canto III. l. 204. It is now diſcovered that pure air, or oxygene, uniting with variety of baſes forms the various kinds of acids; as the vitriolic acid from pure air and ſulphur; the nitrous acid from pure air and phlogiſtic air, or azote; and carbonic acid, (or fixed air,) from pure air and charcoal. Some of theſe affinities were perhaps portrayed by the Magi of Egypt, who were probably learned in chemiſtry, in their hieroglyphic pictures before the invention of letters, by the loves of Jupiter with terreſtrial ladies. And thus phyſically as well as metaphyſically might be ſaid "Jovis omnia plena."

Bears with ſlow ſtep his beauteous prize aloof,
Dips in the lucid flood his ivory hoof;
Then wets his velvet knees, and wading laves
His ſilky ſides amid the dimpling waves.
While her fond train with beckoning hands deplore,
Strain their blue eyes, and ſhriek along the ſhore;
Beneath her robe ſhe draws her ſnowy feet,
And, half-reclining on her ermine ſeat,
Round his raiſed neck her radiant arms ſhe throws,
And reſts her fair cheek on his curled brows;
Her yellow treſſes wave on wanton gales,
And high in air her azure mantle ſails.
—Onward He moves, applauding Cupids guide,
And ſkim on ſhooting wing the ſhining tide;
Emerging Tritons leave their coral caves,
Sound their loud conchs, and ſmooth the circling waves,
Surround the timorous Beauty, as ſhe ſwims,
And gaze enamour'd on her ſilver limbs.
—Now Europe's ſhadowy ſhores with loud acclaim
Hail the fair fugitive, and ſhout her name;
Soft echoes warble, whiſpering foreſts nod,
And conſcious Nature owns the preſent God.
—Changed from the Bull, the rapturous God aſſumes
Immortal youth, with glow celeſtial blooms,
With lenient words her virgin fears diſarms,
And claſps the yielding Beauty in his arms;
Whence Kings and Heroes own illuſtrious birth,
Guards of mankind, and demigods on earth.

VI. "GNOMES! as you paſs'd beneath the labouring ſoil,
The guards and guides of Nature's chemic toil,
*You* ſaw, deep-ſepulchred in duſky realms,
Which Earth's rock-ribbed ponderous vault o'erwhelms,

With ſelf-born fires the maſs fermenting glow,
And flame-wing'd ſulphurs quit the earths below.

1. " *Hence* ductile *Clays* in wide expanſion ſpread,
Soft as the Cygnet's down, their ſnow-white bed;
With yielding flakes ſucceſſive forms reveal,
And change obedient to the whirling wheel.
—Firſt CHINA's ſons, with early art elate,
Form'd the gay tea-pot, and the pictured plate;
Saw with illumin'd brow and dazzled eyes
In the red ſtove vitreſcent colours riſe;
Speck'd her tall beakers with enamel'd ſtars,
Her monſter-joſſes, and gigantic jars;
Smear'd her huge dragons with metallic hues,
With golden purples, and cobaltic blues;
Bade on wide hills her porcelain caſtles glare,
And glazed Pagodas tremble in the air.

"ETRURIA! next beneath thy magic hands
Glides the quick wheel, the plaiſtic clay expands,

*With ſelf-born fires.* l. 275. After the accumulation of plains and mountains on the calcareous rocks or granite which had been previouſly raiſed by volcanic fires, a ſecond ſet of volcanic fires were produced by the fermentation of this new maſs, by which after the ſalts or acids and iron had been waſhed away in part by elutriation, diſſipated the ſulphurous parts which were inſoluble in water; whence argillaceous and ſiliceous earths were left in ſome places; in others, bitumen became ſublimed to the upper part of the ſtratum, producing coals of various degrees of purity.

*Hence ductile clays.* l. 277. See additional notes, No. XX.

*Saw with illumin'd brow.* l. 283. No colour is diſtinguiſhable in the red-hot kiln but the red itſelf, till the workman introduces a ſmall piece of dry wood, which by producing a white flame renders all the other colours viſible in a moment.

*With golden purples.* l. 288. See additional notes, No. XXI.

*Etruria! next.* l. 291. Etruria may perhaps vie with China itſelf in the antiquity of its arts. The times of its greateſt ſplendour were prior

Nerved with fine touch, thy fingers (as it turns)
Mark the nice bounds of vaſes, ewers, and urns;
Round each fair form in lines immortal trace
Uncopied Beauty, and ideal Grace.

"GNOMES! as you now diſſect with hammers fine
The granite-rock, the nodul'd flint calcine;
Grind with ſtrong arm, the circling chertz betwixt,
Your pure Ka-o-lins and Pe-tun-tſes mixt;
O'er each red ſaggars burning cave preſide,
The keen-eyed Fire-Nymphs blazing by your ſide;
And pleaſed on WEDGWOOD ray your partial ſmile,
A new Etruria decks Britannia's iſle.—
Charm'd by your touch, the flint liqueſcent pours
Through finer ſieves, and falls in whiter ſhowers;
Charm'd by your touch, the kneaded clay refines,
The biſcuit hardens, the enamel ſhines;
Each nicer mould a ſofter feature drinks,
The bold Cameo ſpeaks, the ſoft Intaglio thinks.

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to the foundations of Rome, and the reign of one of its beſt princes, Janus, was the oldeſt epoch the Romans knew. The earlieſt hiſtorians ſpeak of the Etruſcans as being then of high antiquity, moſt probably a colony from Phœnicia, to which a Pelaſgian colony acceded, and was united ſoon after Deucalion's flood. The peculiar character of their earthern vaſes conſiſts in the admirable beauty, ſimplicity, and diverſity of forms, which continue the beſt models of taſte to the artiſts of the preſent times; and in a ſpecies of non-vitreous encauſtic painting, which was reckoned, even in the time of Pliny, among the loſt arts of antiquity, but which has lately been recovered by the ingenuity and induſtry of Mr. Wedgwood. It is ſuppoſed that the principal manufactories were about Nola, at the foot of Veſuvius, for it is in that neighbourhood that the greateſt quantities of antique vaſes have been found; and it is ſaid that the general taſte of the inhabitants is apparently influenced by them; inſomuch that ſtrangers coming to Naples, are commonly ſtruck with the diverſity and elegance even of the moſt ordinary vaſes for common uſes. See D'Hancarville's preliminary diſcourſes to the magnificent collection of Etruſcan vaſes, publiſhed by Sir William Hamilton.

"To call the pearly drops from Pity's eye,
Or ſtay Deſpair's diſanimating ſigh,
Whether, O Friend of art! the gem you mould
Rich with new taſte, with antient virtue bold;
Form the poor fetter'd *Slave* on bended knee
From Britain's ſons imploring to be free;
Or with fair HOPE the brightening ſcenes improve,
And cheer the dreary waſtes at Sydney-cove;
Or bid Mortality rejoice and mourn
O'er the fine forms on PORTLAND's myſtic urn.—

———*Here* her ſad Conſort, ſtealing through the gloom
Of murmuring cloyſters, gazes on her tomb;
Hangs in mute anguiſh o'er the ſcutcheon'd hearſe,
Or graves with trembling ſtyle the votive verſe.

"Sexton! oh, lay beneath this ſacred ſhrine,
When Time's cold hand ſhall cloſe my aching eyes,
Oh, gently lay this wearied earth of mine,
Where wrap'd in night my loved MILCENA lies.

"So ſhall with purer joy my ſpirit move,
When the laſt trumpet thrills the caves of Death,
Catch the firſt whiſpers of my waking love,
And drink with holy kiſs her kindling breath.

*Form the poor fetter'd Slave.* l. 315. Alluding to two cameos of Mr. Wedgwood's manufacture; one of a Slave in chains, of which he diſtributed many hundreds, to excite the humane to attend to and to aſſiſt in the abolition of the deteſtable traffic in human creatures; and the other a cameo of Hope attended by Peace, and Art, and Labour; which was made of clay from Botany Bay; to which place he ſent many of them to ſhew the inhabitants what their materials would do, and to encourage their induſtry. A print of this latter medallion is prefixed to Mr. Stockdale's edition of Philip's Expedition to Botany Bay.

*Portland's myſtic urn.* l. 320. See additional notes, No. XXII.

" The ſpotleſs Fair, with bluſh ethereal warm
Shall hail with ſweeter ſmile returning day,
Riſe from her marble bed a brighter form,
And win on buoyant ſtep her airy way.

" Shall bend approved, where beckoning hoſts invite,
On clouds of ſilver her adoring knee,
Approach with Seraphim the throne of light,
—And *Beauty* plead with angel-tongue for *Me!*"

" *Here* by fall'n columns and disjoin'd arcades,
On mouldering ſtones, beneath deſiduous ſhades,
Sits HUMANKIND in hieroglyphic ſtate,
Serious, and pondering on their changeful ſtate;
While with inverted torch, and ſwimming eyes,
Sinks the fair ſhade of *Mortal Life*, and dies.
*There* the pale *Ghoſt* through Death's wide portal bends
His timid feet, the duſky ſteep deſcends;
With ſmiles aſſuaſive *Love Divine* invites,
Guides on broad wing, with torch uplifted lights;
*Immortal Life*, her hand extending, courts
The lingering form, his tottering ſtep ſupports;
Leads on to Pluto's realms the dreary way,
And gives him trembling to Elyſian day.
*Beneath*, in ſacred robes the PRIESTESS dreſs'd,
The coif cloſe-hooded, and the fluttering veſt,
With pointing finger guides the initiate youth,
Unweaves the many-colour'd veil of Truth,
Drives the profane from Myſtery's bolted door,
And Silence guards the Eleuſinian lore.—

" Whether, O Friend of Art! your gems derive
Fine forms from Greece, and fabled Gods revive;
Or bid from modern life the Portrait breathe,
And bind round Honour's brow the laurel wreath;
Buoyant ſhall ſail, with Fame's hiſtoric page,
Each fair medallion o'er the wrecks of age;
Nor Time ſhall mar; nor ſteel, nor fire, nor ruſt
Touch the hard poliſh of the immortal buſt.

2. " *Hence* ſable Coal his maſſy couch extends,
And ſtars of gold the ſparkling Pyrite blends;
Hence dull-eyed Naphtha pours his pitchy ſtreams,
And Jet uncolour'd drinks the ſolar beams,
Bright Amber ſhines on his electric throne,
And adds ethereal luſtres to his own.

*Fine forms from Greece.* l. 362. In real ſtones, or in paſte or ſoft coloured glaſs, many pieces of exquiſite workmanſhip were produced by the antients. Baſſo-relievos of various ſizes were made in coarſe brown earth of one colour; but of the improved kind of two or more colours, and of a true porcelain texture, none were made by the antients, nor attempted I believe by the moderns, before thoſe of Mr. Wedgwood's manufactory.

*Hence ſable Coal.* l. 369. See additional notes, No. XXIII. on coal.

*Bright Amber ſhines.* l. 373. Coal has probably all been ſublimed more or leſs from the clay, with which it was at firſt formed in decompoſing moraſſes; the petroleum ſeems to have been ſeparated and condenſed again in ſuperior ſtrata, and a ſtill finer kind of oil, as naphtha, has probably had the ſame origin. Some of theſe liquid oils have again loſt their more volatile parts, and become cannel-coal, aſphaltum, jet, and amber, according to the purity of the original foſſil oil. Dr. Prieſtley has ſhewn, that eſſential oils long expoſed to the atmoſphere abſorb both the vital and phlogiſtic part of it; whence it is probable their becoming ſolid may in great meaſure depend, as well as by the exhalation of their more volatile parts. On diſtillation with volatile alcaly all theſe foſſil oils are ſhewn to contain the acid of amber, which evinces the identity of their origin. If a piece of amber be rubbed it attracts ſtraws and hairs, whence the diſcovery of electricity, and whence its name, from electron the Greek word for amber.

—Led by the phoſphor-light, with daring tread
Immortal **Franklin** ſought the fiery bed;
Where, nurſed in night, incumbent Tempeſt ſhrouds
The ſeeds of Thunder in circumfluent clouds,
Beſieged with iron points his airy cell,
And pierced the monſter ſlumbering in the ſhell.

“ So, borne on ſounding pinions to the *Weſt*,
When Tyrant-Power had built his eagle neſt;
While from his eyry ſhriek'd the famiſh'd brood,
Clenched their ſharp claws, and champ'd their beaks for blood,
Immortal **Franklin** watch'd the callow crew,
And ſtabb'd the ſtruggling Vampires, ere they flew.
—The patriot-flame with quick contagion ran,
Hill lighted hill, and man electriſed man;
Her heroes ſlain awhile **Columbia** mourn'd,
And crown'd with laurels *Liberty* return'd.

“ The Warrior, *Liberty*, with bending ſails
Helm'd his bold courſe to fair **Hibernia**'s vales;—
Firm as he ſteps, along the ſhouting lands,
Lo! Truth and Virtue range their radiant bands;
Sad Superſtition wails her empire torn,
Art plies his oar, and Commerce pours her horn.

“ Long had the Giant-form on **Gallia**'s plains
Inglorious ſlept, unconſcious of his chains;
Round his large limbs were wound a thouſand ſtrings
By the weak hands of Confeſſors and Kings;
O'er his cloſed eyes a triple veil was bound,
And ſteely rivets lock'd him to the ground;

*Immortal Franklin*. l. 385. See note on Canto I. l. 385.

While ſtern Baſtile with iron cage inthralls
His folded limbs, and hems in marble walls.
—Touch'd by the patriot-flame, he rent amazed
The flimſy bonds, and round and round him gazed;
Starts up from earth, above the admiring throng
Lifts his Coloſſal form, and towers along;
High o'er his foes his hundred arms He rears,
Plowſhares his ſwords, and pruning hooks his ſpears;
Calls to the Good and Brave with voice, that rolls
Like Heaven's own thunder round the echoing poles;
Gives to the winds his banner broad unfurl'd,
And gathers in its ſhade the living world!

VII. "*Gnomes! you* then taught volcanic airs to force
Through bubbling Lavas their reſiſtleſs courſe,
O'er the broad walls of rifted Granite climb,
And pierce the rent roof of incumbent Lime,

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*While ſtern Baſtile.* l. 403. "We deſcended with great difficulty into the dungeons, which were made too low for our ſtanding upright; and were ſo dark, that we were obliged at noon-day to viſit them by the light of a candle. We ſaw the hooks of thoſe chains, by which the priſoners were faſtened by their necks to the walls of their cells; many of which being below the level of the water were in a conſtant ſtate of humidity; from which iſſued a noxious vapour, which more than once extinguiſhed the candles. Since the deſtruction of the building many ſubterraneous cells have been diſcovered under a piece of ground, which ſeemed only a bank of ſolid earth before the horrid ſecrets of this priſon-houſe were diſcloſed. Some ſkeletons were found in theſe receſſes with irons ſtill faſtened to their decayed bones." Letters from France, by H. M. Williams, p. 24.

*And pierce the rent roof.* l. 418. The granite rocks and the limeſtone rocks have been cracked to very great depths at the time they were raiſed up by ſubterranean fires; in theſe cracks are found moſt of the metallic ores, except iron and perhaps manganeſe, the former of which is generally found in horizontal ſtrata, and the latter generally near the ſurface of the earth.

Round ſparry caves metallic luſtres fling,
And bear phlogiſton on their tepid wing. 420

Philoſophers poſſeſſing ſo convenient a teſt for the diſcovery of iron by the magnet, have long ſince found it in all vegetable and animal matters; and of late Mr. Scheele has diſcovered the exiſtence of manganeſe, in vegetable aſhes. Scheele, 56 mem. Stock. 1774. Kirwan. Min. 353. Which accounts for the production of it near the ſurface of earth, and thence for its calciform appearance, or union with vital air. Bergman has likewiſe ſhewn, that the limeſtones which become bluiſh or dark coloured when calcined, poſſeſs a mixture of manganeſe, and are thence preferable as a cement to other kinds of lime. 2. Bergman, 229. Which impregnation with manganeſe has probably been received from the decompoſition of ſuperincumbent vegetable matters.

Theſe cracks or perpendicular caverns in the granite or limeſtone paſs to unknown depths; and it is up theſe channels that I have endeavoured to ſhew that the ſteam riſes which becomes afterwards condenſed and produces the warm ſprings of this iſland, and other parts of the world. (See note on Fucus, Vol. II.) And up theſe cracks I ſuppoſe certain vapours ariſe, which either alone, or by meeting with ſomething deſcending into them from above, have produced moſt of the metals; and ſeveral of the materials in which they are bedded. Thus the ponderous earth, Barytes, of Derbyſhire, is found in theſe cracks, and is ſtratified frequently with lead-ore, and frequently ſurrounds it. This ponderous earth has been found by Dr. Hoepſner in a granite in Switzerland, and may have thus been ſublimed from immenſe depths by great heat, and have obtained its carbonic or vitriolic acid from above. Annales de Chimie. There is alſo reaſon to conclude that ſomething from above is neceſſary to the formation of many of the metals: at Hawkſtone in Shropſhire, the ſeat of Sir Richard Hill, there is an elevated rock of ſiliceous ſand which is coloured green with copper in many places high in the air; and I have in my poſſeſſion a ſpecimen of lead formed in the cavity of an iron nodule, and another of lead amid ſpar from a crack of a coal-ſtratum; all which countenance the modern production of thoſe metals from deſcending materials. To which ſhould be added that the higheſt mountains of granite which have therefore probably never been covered with marine productions on account of their early elevation, nor with vegetable or animal matters on account of their great coldneſs, contain no metallic ores, whilſt the lower ones contain copper and tin in their cracks or veins, both in Saxony, Sileſia, and Cornwall. Kirwan's Mineral. p. 374.

The tranſmutation of one metal into another, though hitherto undiſcovered by the alchymiſts, does not appear impoſſible; ſuch tranſmuta-

“ *Hence* glows, refulgent Tin! thy chryſtal grains,
And tawny Copper ſhoots her azure veins;
Zinc lines his fretted vault with ſable ore,
And dull Galena teſſellates the floor;
On vermil beds in Idria's mighty caves 425
The living Silver rolls its ponderous waves;
With gay refractions bright Platina ſhines,
And ſtuds with ſquander'd ſtars his duſky mines;
Long threads of netted gold, and ſilvery darts,
Inlay the Lazuli, and pierce the Quartz;— 430
—Whence roof'd with ſilver beam'd PERU, of old,
And hapleſs MEXICO was paved with gold.

“ Heavens! on my ſight what ſanguine colours blaze!
Spain's deathleſs ſhame! the crimes of modern days!
When Avarice, ſhrouded in Religion's robe, 435
Sail'd to the Weſt, and ſlaughter'd half the globe;
While Superſtition, ſtalking by his ſide,
Mock'd the loud groans, and lap'd the bloody tide;
For ſacred truths announced her frenzied dreams,
And turn'd to night the ſun's meridian beams.— 440
Hear, Oh, BRITANNIA! potent Queen of iſles,
On whom fair Art, and meek Religion ſmiles,
Now AFRIC's coaſts thy craftier ſons invade
With murder, rapine, theſt,—and call it Trade!

tions have been ſuppoſed to exiſt in nature, thus lapis calaminaris may have been produced from the deſtruction of lead-ore, as it is generally found on the top of the veins of lead, where it has been calcined or united with air, and becauſe maſſes of lead-ore are often found entirely incloſed in it. So ſilver is found mixed in almoſt all lead-ores, and ſometimes in ſeparate filaments within the cavities of lead-ore, as I am informed by Mr. Michell, and is thence probably a partial tranſmutation of the lead to ſilver, the rapid progreſs of modern chemiſtry having ſhewn the analogy between metallic calces and acids, may lead to the power of tranſmuting their baſes: a diſcovery much to be wiſhed.

—The *Slave*, in chains, on ſupplicating knee,
Spreads his wide arms, and lifts his eyes to Thee;
With hunger pale, with wounds and toil oppreſs'd,
"*Are we not Brethren?*" ſorrow choaks the reſt;—
*Air!* bear to heaven upon thy azure flood
Their innocent cries!—*Earth!* cover not their blood!

VIII. "When Heaven's dread juſtice ſmites in crimes o'ergrown
The blood-nurſed Tyrant on his purple throne,
*Gnomes! your* bold forms unnumber'd arms outſtretch,
And urge the vengeance o'er the guilty wretch.—
Thus when Cambyses led his barbarous hoſts
From Perſia's rocks to Egypt's trembling coaſts,
Defiled each hallowed fane, and ſacred wood,
And, drunk with fury, ſwell'd the Nile with blood;
Waved his proud banner o'er the Theban ſtates,
And pour'd deſtruction through her hundred gates;
In dread diviſions march'd the marſhal'd bands,
And ſwarming armies blacken'd all the lands,
By Memphis theſe to Ethiop's ſultry plains,
And thoſe to Hammon's ſand-incircled ſanes.—
Slow as they paſs'd, the indignant temples frown'd,
Low curſes muttering from the vaulted ground;
Long ailes of Cypreſs waved their deepen'd glooms,
And quivering ſpectres grinn'd amid the tombs,

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*Thus when Cambyſes.* l. 455. Cambyſes marched one army from Thebes, after having overturned the temples, ravaged the country, and deluged it with blood, to ſubdue Ethiopia; this army almoſt periſhed by famine, inſomuch, that they repeatedly ſlew every tenth man to ſupply the remainder with food. He ſent another army to plunder the temple of Jupiter Ammon, which periſhed overwhelm'd with ſand.

Prophetic whiſpers breathed from SPHINX's tongue,
And MEMNON's lyre with hollow murmurs rung;
Burſt from each pyramid expiring groans,
And darker ſhadows ſtretch'd their lengthen'd cones.—
Day after day their dreadful rout They ſteer,
Luſt in the van, and rapine in the rear.

" *Gnomes!* as they march'd, *You* bid the gather'd fruits,
The bladed graſs, ſweet grains, and mealy roots;
Scared the tired quails, that journey'd o'er their heads,
Retain'd the locuſts in their earthy beds;
Bade on your ſands no night-born dews diſtil,
Stay'd with vindictive hands the ſcanty rill.—
Loud o'er the camp the Fiend of Famine ſhrieks,
Calls all her brood, and champs her hundred beaks;
O'er ten ſquare leagues her pennons broad expand,
And twilight ſwims upon the ſhuddering ſand;
Perch'd on her creſt the Griffin Diſcord clings,
And Giant Murder rides between her wings;
Blood from each clotted hair, and horny quill,
And ſhowers of tears in blended ſtreams diſtil;
High-poiſed in air her ſpiry neck ſhe bends,
Rolls her keen eye, her Dragon-claws extends,
Darts from above, and tears at each fell ſwoop
With iron fangs the decimated troop.

" Now o'er their head the whizzing whirlwinds breathe,
And the live deſert pants, and heaves beneath;
Tinged by the crimſon ſun, vaſt columns riſe
Of eddying ſands, and war amid the ſkies,

In red arcades the billowy plain ſurround,
And ſtalking turrets dance upon the ground.

*And ſtalking turrets.* l. 498. "At one o'clock we alighted among ſome acacia trees at Waadi el Halboub, having gone twenty-one miles. We were here at once ſurpriſed and terrified by a ſight ſurely one of the moſt magnificent in the world. In that vaſt expanſe of deſert, from W. to N. W. of us, we ſaw a number of prodigious pillars of ſand at different diſtances, at times moving with great celerity, at others ſtalking on with a majeſtic ſlowneſs; at intervals we thought they were coming in a very few minutes to overwhelm us; and ſmall quantities of ſand did actually more than once reach us. Again they would retreat ſo as to be almoſt out of ſight, their tops reaching to the very clouds. There the tops often ſeparated from the bodies; and theſe, once disjoined, diſperſed in the air, and did not appear more. Sometimes they were broken in the middle, as if ſtruck with large cannon-ſhot. About noon they began to advance with conſiderable ſwiftneſs upon us, the wind being very ſtrong at north. Eleven of them ranged along ſide of us about the diſtance of three miles. The greateſt diameter of the largeſt appeared to me at that diſtance as if it would meaſure ten feet. They retired from us with a wind at S. E. leaving an impreſſion upon my mind to which I can give no name, though ſurely one ingredient in it was fear, with a conſiderable deal of wonder and aſtoniſhment. It was in vain to think of flying; the ſwifteſt horſe, or faſteſt ſailing ſhip, could be of no uſe to carry us out of this danger; and the full perſuaſion of this rivetted me as if to the ſpot where I ſtood.

"The ſame appearance of moving pillars of ſand preſented themſelves to us this day in form and diſpoſition like thoſe we had ſeen at Waadi Halboub, only they ſeemed to be more in number and leſs in ſize. They came ſeveral times in a direction cloſe upon us, that is, I believe, within leſs than two miles. They began immediately after ſun-riſe like a thick wood and almoſt darkened the ſun. His rays ſhining through them for near an hour, gave them an appearance of pillars of fire. Our people now became deſperate, the Greeks ſhrieked out and ſaid it was the day of judgment; Iſmael pronounced it to be hell; and the Turcorories, that the world was on fire." Bruce's Travels, Vol. IV. p. 553,—555.

From this account it would appear, that the eddies of wind were owing to the long range of broken rocks, which bounded one ſide of the ſandy deſert, and bent the currents of air, which ſtruck againſt their ſides; and were thus like the eddies in a ſtream of water, which falls againſt oblique obſtacles. This explanation is probably the true one, as theſe whirl-winds were not attended with rain or lightening like the tornadoes of the Weſt-Indies.

—Long ranks in vain their ſhining blades extend,
To Demon-Gods their knees unhallow'd bend, 500
Wheel in wide circle, form in hollow ſquare,
And now they front, and now they fly the war,
Pierce the deaf tempeſt with lamenting cries,
Preſs their parch'd lips, and cloſe their blood-ſhot eyes.
—*Gnomes!* o'er the waſte *you* led your myriad powers, 505
Climb'd on the whirls, and aim'd the flinty ſhowers!—
Onward reſiſtleſs rolls the infuriate ſurge,
Clouds follow clouds, and mountains mountains urge;
Wave over wave the driving deſert ſwims,
Burſts o'er their heads, inhumes their ſtruggling limbs; 510
Man mounts on man, on camels camels ruſh,
Hoſts march o'er hoſts, and nations nations cruſh,—
Wheeling in air the winged iſlands fall,
And one great earthy Ocean covers all!—
Then ceaſed the ſtorm,—*Night* bow'd his Ethiop brow 515
To earth, and liſten'd to the groans below,—
Grim HORROR ſhook,—awhile the living hill
Heaved with convulſive throes,—and all was ſtill!

IX. "*Gnomes!* whoſe fine forms, impaſſive as the air,
Shrink with ſoft ſympathy for human care; 520
Who glide unſeen, on printleſs ſlippers borne,
Beneath the weaving graſs, and nodding corn;
Or lay your tiny limbs, when noon-tide warms,
Where ſhadowy cowſlips ſtretch their golden arms,—
So mark'd on orreries in lucid ſigns, 525
Star'd with bright points the mimic zodiac ſhines;

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*So mark'd on orreries.* l. 525. The firſt orrery was conſtructed by a Mr. Rowley, a mathematician born at Litchfield; and ſo named from his patron the Earl of Orrery. Johnſon's Dictionary.

Borne on fine wires amid the pictured ſkies
With ivory orbs the planets ſet and riſe :
Round the dwarf earth the pearly moon is roll'd,
And the ſun twinkling whirls his rays of gold.—
Call your bright myriads, march your mailed hoſts,
With ſpears and helmets glittering round the coaſts ;
Thick as the hairs, which rear the Lion's mane,
Or fringe the Boar, that bays the hunter-train ;
Watch, where proud Surges break their treacherous mounds,
And ſweep reſiſtleſs o'er the cultured grounds ;
Such as erewhile, impell'd o'er Belgia's plain,
Roll'd her rich ruins to the inſatiate main ;
With piles and piers the ruffian waves engage,
And bid indignant Ocean ſtay his rage.

" Where, girt with clouds, the rifted mountain yawns,
And chills with length of ſhade the gelid lawns,
Climb the rude ſteeps, the granite-cliffs ſurround,
Pierce with ſteel points, with wooden wedges wound ;

*The granite-cliffs.* l. 543. On long expoſure to air the granites or porphories of this country exhibit a ferrugenous cruſt, the iron being calcined by the air firſt becomes viſible, and is then waſhed away from the external ſurface, which becomes white or grey, and thus in time ſeems to decompoſe. The marbles ſeem to decompoſe by loſing their carbonic acid, as the outſide, which has been long expoſed to the air, does not ſeem to effervеſce ſo haſtily with acids as the parts more recently broken. The immenſe quantity of carbonic acid, which exiſts in the many provinces of lime-ſtone, if it was extricated and decompoſed would afford charcoal enough for fuel for ages, or for the production of new vegetable or animal bodies. The volcanic flaggs on Mount Veſuvius are ſaid by M. Ferber to be changed into clay by means of the ſulphur-acid, and even pots made of clay and burnt or vitrified are ſaid by him to be again reducible to ductile clay by the volcanic ſteams. Ferber's travels through Italy, p. 166.

*Woode wedges wound.* l. 524. It is uſual in ſeparating large mill-ſtones from the ſiliceous ſand-rocks in ſome parts of Derbyſhire to bore hori-

Break into clays the ſoft volcanic ſlaggs;
Or melt with acid airs the marble craggs;
Crown the green ſummits with adventurous flocks,
And charm with novel flowers the wondering rocks.
—So when proud Rome the Afric Warrior braved,
And high on Alps his crimſon banner waved;
While rocks on rocks their beetling brows oppoſe
With piny foreſts, and unfathomed ſnows;
Onward he march'd, to Latium's velvet ground
With fires and acids burſt the obdurate bound,
Wide o'er her weeping vales deſtruction hurl'd,
And ſhook the riſing empire of the world.

X. " Go, gentle *Gnomes!* reſume your vernal toil,
Seek my chill tribes, which ſleep beneath the ſoil;
On grey-moſs banks, green meads, or furrow'd lands
Spread the dark mould, white lime, and crumbling ſands;
Each burſting bud with healthier juices feed,
Emerging ſcion, or awaken'd ſeed.
So, in deſcending ſtreams, the ſilver Chyle
Streaks with white clouds the golden floods of bile;

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zontal holes under them in a circle, and fill theſe with pegs made of dry wood, which gradually ſwell by the moiſture of the earth, and in a day or two lift up the mill-ſtone without breaking it.

*With fires and acids.* l. 554. Hannibal was ſaid to erode his way over the Alps by fire and vinegar. The latter is ſuppoſed to allude to the vinegar and water which was the beverage of his army. In reſpect to the former it is not improbable, but where wood was to be had in great abundance, that fires made round lime-ſtone precipices would calcine them to a conſiderable depth, the night-dews or mountain-miſts would penetrate theſe calcined parts and pulverize them by the force of the ſteam which the generated heat would produce, the winds would diſperſe this lime-powder, and thus by repeated fires a precipice of lime-ſtone might be deſtroyed and a paſſage opened. It ſhould be added, that according to Ferber's obſervations, theſe Alps conſiſt of limeſtone. Letters from Italy.

Through each nice valve the mingling currents glide,
Join their fine rills, and ſwell their ſanguine tide;
Each countleſs cell, and viewleſs fibre ſeek,
Nerve the ſtrong arm, and tinge the bluſhing cheek.

"Oh, watch, where boſom'd in the teeming earth,
Green ſwells the germ, impatient for its birth;
Guard from rapacious worms its tender ſhoots,
And drive the mining beetle from its roots;
With ceaſeleſs efforts rend the obdurate clay,
And give my vegetable babes to day!
—Thus when an Angel-form, in light array'd,
Like HOWARD pierced the priſon's noiſome ſhade;
Where chain'd to earth, with eyes to heaven upturn'd,
The kneeling Saint in holy anguiſh mourn'd;—
Ray'd from his lucid veſt, and halo'd brow
O'er the dark roof celeſtial luſtres glow,
"PETER, ariſe!" with cheering voice He calls,
And ſounds ſeraphic echo round the walls;
Locks, bolts, and chains his potent touch obey,
And pleaſed he leads the dazzled Sage to day.

XI. "*You!* whoſe fine fingers fill the organic cells,
With virgin earth, of woods and bones and ſhells;
Mould with retractile glue their ſpongy beds,
And ſtretch and ſtrengthen all their fibre-threads.—

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*Mould with retractile glue.* l. 587. The conſtituent parts of animal fibres are believed to be earth and gluten. Theſe do not ſeparate except by long putrefaction or by fire. The earth then effervеſces with acids, and can only be converted into glaſs by the greateſt force of fire. The gluten has continued united with the earth of the bones above 2000 years in Egyptian mummies; but by long expoſure to air or moiſture it diſſolves and leaves only the earth. Hence bones long buried, when expoſed to the air, abſorb moiſture and crumble into powder. Phil. Tranſ. No. 475. The retractibility or elaſticity of the animal fibre de-

Late when the maſs obeys its changeful doom,
And ſinks to earth, its cradle and its tomb, 590
*Gnomes!* with nice eye the ſlow ſolution watch,
With foſtering hand the parting atoms catch,
Join in new forms, combine with life and ſenſe,
And guide and guard the tranſmigrating Ens.

pends on the gluten; and of theſe fibres are compoſed the membranes muſcles and bones. Haller. Phyſiol. Tom. I. p. 2.

For the chemical decompoſition of animal and vegetable bodies ſee the ingenious work of Lavoiſier, Traité de Chimie, Tom. I. p. 132. who reſolves all their component parts into oxygene, hydrogene, carbone, and azote, the three former of which belong principally to vegetable and the laſt to animal matter.

*The tranſmigrating Ens.* l. 594. The perpetual circulation of matter in the growth and diſſolution of vegetable and animal bodies ſeems to have given Pythagoras his idea of the metempſycoſis or tranſmigration of ſpirit; which was afterwards dreſſed out or ridiculed in variety of amuſing fables. Other philoſophers have ſuppoſed, that there are two different materials or eſſences, which fill the univerſe. One of theſe, which has the power of commencing or producing motion, is called ſpirit; the other, which has the power of receiving and of communicating motion, but not of beginning it, is called matter. The former of theſe is ſuppoſed to be diffuſed through all ſpace, filling up the interſtices of the ſuns and planets, and conſtituting the gravitations of the ſideral bodies, the attractions of chemiſtry, with the ſpirit of vegetation, and of animation. The latter occupies comparatively but ſmall ſpace, conſtituting the ſolid parts of the ſuns and planets, and their atmoſpheres. Hence theſe philoſophers have ſuppoſed, that both matter and ſpirit are equally immortal and unperiſhable; and that on the diſſolution of vegetable or animal organization, the matter returns to the general maſs of matter; and the ſpirit to the general maſs of ſpirit, to enter again into new combinations, according to the original idea of Pythagoras.

The ſmall apparent quantity of matter that exiſts in the univerſe compared to that of ſpirit, and the ſhort time in which the recrements of animal or vegetable bodies become again vivified in the forms of vegetable mucor or microſcopic inſects, ſeems to have given riſe to another curious fable of antiquity. That Jupiter threw down a large handful of ſouls upon the earth, and left them to ſcramble for the few bodies which were to be had.

" So when on Lebanon's ſequeſter'd hight
The fair ADONIS left the realms of light,
Bow'd his bright locks, and, fated from his birth
To change eternal, mingled with the earth ;—
With darker horror ſhook the conſcious wood,
Groan'd the ſad gales, and rivers bluſh'd with blood ;
On cypreſs-boughs the Loves their quivers hung,
Their arrows ſcatter'd, and their bows unſtrung ;
And *Beauty's Goddeſs*, bending o'er his bier,
Breathed the ſoft ſigh, and pour'd the tender tear.—
Admiring PROSERPINE through duſky glades
Led the fair phantom to Elyſian ſhades,
Clad with new form, with finer ſenſe combined,
And lit with purer flame the ethereal mind.
—Erewhile, emerging from infernal night,
The bright Aſſurgent riſes into light,

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*Adonis*. l. 596. The very antient ſtory of the beautiful Adonis paſſing one half of the year with Venus, and the other with Proſerpine alternately, has had variety of interpretations. Some have ſuppoſed that it allegorized the ſummer and winter ſolſtice ; but this ſeems too obvious a fact to have needed an hieroglyphic emblem. Others have believed it to repreſent the corn, which was ſuppoſed to ſleep in the earth during the winter months, and to riſe out of it in ſummer. This does not accord with the climate of Egypt, where the harveſt ſoon follows the ſeed-time.

It ſeems more probably to have been a ſtory explaining ſome hieroglyphic figures repreſenting the decompoſition and reſuſcitation of animal matter ; a ſublime and intereſting ſubject, and which ſeems to have given origin to the doctrine of the tranſmigration, which had probably its birth alſo from the hieroglyphic treaſures of Egypt. It is remarkable that the cypreſs groves in the antient greek writers, as in Theocritus, were dedicated to Venus; and afterwards became funeral emblems. Which was probably occaſioned by the Cypreſs being an accompaniment of Venus in the annual proceſſions, in which ſhe was ſuppoſed to lament over the funeral of Adonis ; a ceremony which obtained over all the eaſtern world from great antiquity, and is ſuppoſed to be referred to by Ezekiel, who accuſes the idolatrous woman of weeping for Thammus.

Leaves the drear chambers of the inſatiate tomb,
And ſhines and charms with renovated bloom.—
While wondering Loves the burſting grave ſurround,
And edge with meeting wings the yawning ground,
Stretch their fair necks, and leaning o'er the brink
View the pale regions of the dead, and ſhrink;
Long with broad eyes ecſtatic *Beauty* ſtands,
Heaves her white boſom, ſpreads her waxen hands;
Then with loud ſhriek the panting Youth alarms,
"My Life! my Love!" and ſprings into his arms."

The *Goddeſs* ceaſed,—the delegated throng
O'er the wide plains delighted ruſh along;
In duſky ſquadrons, and in ſhining groups,
Hoſts follow hoſts, and troops ſucceed to troops;
Scarce bears the bending graſs the moving freight,
And nodding florets bow beneath their weight.
So when light clouds on airy pinions ſail,
Flit the ſoft ſhadows o'er the waving vale;
Shade follows ſhade, as laughing Zephyrs drive,
And all the chequer'd landſcape ſeems alive.

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*Zephyrs drive.* l. 629. Theſe lines were originally written thus,

Shade follows ſhade by laughing Zephyrs drove,
And all the chequer'd landſcape ſeems to move.

but were altered on account of the ſuppoſed falſe grammar in uſing the word drove for driven, according to the opinion of Dr. Lowth: at the ſame time it may be obſerved, 1. that this is in many caſes only an ellipſis of the letter *n* at the end of the word; as froze, for frozen; wove, for woven; ſpoke, for ſpoken; and that then the participle accidentally becomes ſimilar to the paſt tenſe: 2. that the language ſeems gradually tending to omit the letter *n* in other kind of words for the ſake of euphony; as houſen is become houſes; eyne, eyes; thine, thy, &c. and in common converſation, the words forgot, ſpoke, froze, rode, are frequently uſed for forgotten, ſpoken, frozen, ridden. 3. It does not appear that any confuſion would follow the indiſcriminate uſe of the ſame word for the paſt tenſe and the participle paſſive, ſince the auxiliary verb *have*, or the preceding noun or pronoun always clearly diſtinguiſhes them: and laſtly, rhime-poetry muſt loſe the uſe of many elegant words without this licenſe.

# ARGUMENT

## OF THE

# THIRD CANTO.

ADDRESS to the Nymphs. I. Steam riſes from the ocean, floats in clouds, deſcends in rain and dew, or is condenſed on hills, produces ſprings, and rivers, and returns to the ſea. So the blood circulates through the body and returns to the heart. 11. II. 1. Tides, 57. 2. Echinus, nautilus, pinna, cancer. Grotto of a mermaid. 65. 3. Oil ſtills the waves. Coral rocks. Ship-worm, or Teredo. Maelſtrome, a whirlpool on the coaſt of Norway. 85. III. Rivers from beneath the ſnows on the Alps. The Tiber. 103. IV. Overflowing of the Nile from African Monſoons, 129. V. 1. Gieſar, a boiling fountain in Iceland, deſtroyed by inundation, and conſequent earthquake, 145. 2. Warm medicinal ſprings. Buxton. Duke and Dutcheſs of Devonſhire. 157. VI. Combination of vital air and inflammable gas produces water. Which is another ſource of ſprings and rivers. Allegorical loves of Jupiter and Juno productive of vernal ſhowers. 201. VII. Aquatic Taſte. Diſtant murmur of the ſea by night. Sea-horſe. Nereid ſinging. 261. VIII. The Nymphs of the river Derwent lament the death of Mrs. French, 297. IX. Inland navigation. Monument for Mr. Brindley, 321. X. Pumps explained. Child ſucking. Mothers exhorted to nurſe their children. Cherub ſleeping. 345. XI. Engines for extinguiſhing fire. Story of two lovers periſhing in the flames. 377. XII. Charities of Miſs Jones, 427. XIII. Marſhes drained. Hercules conquers Achilous. The horn of Plenty. 463. XIV. Showers. Dews. Floating lands with water. Lacteal ſyſtem in animals. Caravan drinking. 509. Departure of the Nymphs like water ſpiders; like northern nations ſkaiting on the ice. 549.

## THE

# ECONOMY

## OF

# VEGETATION.

## CANTO III.

AGAIN the *Goddeſs* ſpeaks!—glad Echo ſwells
The tuneful tones along her ſhadowy dells,
Her wrinkling founts with ſoft vibration ſhakes,
Curls her deep wells, and rimples all her lakes,
Thrills each wide ſtream, Britannia's iſle that laves, 5
Her headlong cataracts, and circumfluent waves.
—Thick as the dews, which deck the morning flowers,
Or rain-drops twinkling in the ſun-bright ſhowers,
Fair Nymphs, emerging in pellucid bands,
Riſe, as ſhe turns, and whiten all the lands. 10

I. "*Your* buoyant troops on dimpling ocean tread,
Wafting the moiſt air from his oozy bed,

AQUATIC NYMPHS !—*you* lead with viewleſs march
The winged vapours up the aerial arch,
On each broad cloud a thouſand ſails expand,
And ſteer the ſhadowy treaſure o'er the land,

*The winged vapours.* l. 14. See additional note No. XXV. on evaporation.

*On each broad cloud.* l. 15. The clouds conſiſt of condenſed vapour, the particles of which are too ſmall ſeparately to overcome the tenacity of the air, and which therefore do not deſcend. They are in ſuch ſmall ſpheres as to repel each other, that is, they are applied to each other by ſuch very ſmall ſurfaces, that the attraction of the particles of each drop to its own centre is greater than its attraction to the ſurface of the drop in its vicinity; every one has obſerved with what difficulty ſmall ſpherules of quickſilver can be made to unite, owing to the ſame cauſe; and it is common to ſee on riding through ſhallow water on a clear day, numbers of very ſmall ſpheres of water as they are thrown from the horſes feet run along the ſurface for many yards before they again unite with it. In many caſes theſe ſpherules of water, which compoſe clouds, are kept from uniting by a ſurplus of electric fluid; and fall in violent ſhowers as ſoon as that is withdrawn from them, as in thunder ſtorms. See note on Canto I. l. 554.

If in this ſtate a cloud becomes frozen, it is torn to pieces in its deſcent by the friction of the air, and falls in white flakes of ſnow. Or theſe flakes are rounded by being rubbed together by the winds, and by having their angles thawed off by the warmer air beneath as they deſcend; and part of the water produced by theſe angles thus diſſolved is abſorbed into the body of the hailſtone, as may be ſeen by holding a lump of ſnow over a candle, and there becomes frozen into ice by the quantity of cold which the hailſtone poſſeſſes beneath the freezing point, or which is produced by its quick evaporation in falling; and thus hailſtones are often found of greater or leſs denſity according as they conſiſt of a greater portion of ſnow or ice. If hailſtones conſiſted of the large drops of ſhowers frozen in their deſcent, they would conſiſt of pure tranſparent ice.

As hail is only produced in ſummer, and is always attended with ſtorms, ſome philoſophers have believed that the ſudden departure of electricity from a cloud may effect ſomething yet unknown in this phenomenon; but it may happen in ſummer independent of electricity, becauſe the aqueous vapour is then raiſed higher in the atmoſphere, whence it has further to fall, and there is warmer air below for it to fall through.

Through vernal ſkies the gathering drops diffuſe,
Plunge in ſoft rains, or ſink in ſilver dews.—
*Your* lucid bands condenſe with fingers chill
The blue miſt hovering round the gelid hill; 20

*Or ſink in ſilver dews.* l. 18. During the coldneſs of the night the moiſture before diſſolved in the air is gradually precipitated, and as it ſubſides adheres to the bodies it falls upon. Where the attraction of the body to the particles of water is greater than the attractions of thoſe particles to each other, it becomes ſpread upon their ſurface, or ſlides down them in actual contact; as on the broad parts of the blades of moiſt graſs: where the attraction of the ſurface to the water is leſs than the attraction of the particles of water to each other, the dew ſtands in drops; as on the points and edges of graſs or gorſe, where the ſurface preſented to the drop being ſmall it attracts it ſo little as but juſt to ſupport it without much changing its globular form: where there is no attraction between the vegetable ſurface and the dew drops, as on cabbage leaves, the drop does not come into contact with the leaf, but hangs over it repelled, and retains its natural form, compoſed of the attraction and preſſure of its own parts, and thence looks like quickſilver, reflecting light from both its ſurfaces. Nor is this owing to any oilineſs of the leaf, but ſimply to the poliſh of its ſurface, as a light needle may be laid on water in the ſame manner without touching it; for as the attractive powers of poliſhed ſurfaces are greater when in actual contact, ſo the repulſive power is greater before contact.

*The blue miſt.* l. 20. Miſts are clouds reſting on the ground, they generally come on at the beginning of night, and either fill the moiſt vallies, or hang on the ſummits of hills, according to the degree of moiſture previouſly diſſolved, and the eduction of heat from them. The air over rivers during the warmth of the day ſuſpends much moiſture, and as the changeful ſurface of rivers occaſions them to cool ſooner than the land at the approach of evening, miſts are moſt frequently ſeen to begin over rivers, and to ſpread themſelves over moiſt grounds, and fill the vallies, while the miſts on the tops of mountains are more properly clouds, condenſed by the coldneſs of their ſituation.

On aſcending up the ſide of a hill from a miſty valley, I have obſerved a beautiful coloured halo round the moon when a certain thickneſs of miſt was over me, which ceaſed to be viſible as ſoon as I emerged out of it; and well remember admiring with other ſpectators the ſhadow of the three ſpires of the cathedral church at Lichfield, the moon riſing behind it, apparently broken off, and lying diſtinctly over our heads as if horizontally on the ſurface of the miſt, which aroſe about as high as the roof of the church. There are ſome curious remarks on ſhadows

In clay-form'd beds the trickling ſtreams collect,
Strain through white ſands, through pebbly veins direct;
Or point in rifted rocks their dubious way,
And in each bubbling fountain riſe to day.

" *Nymphs! you* then guide, attendant from their ſource,
The aſſociate rills along their ſinuous courſe; 26
Float in bright ſquadrons by the willowy brink,
Or circling ſlow in limpid eddies ſink;
Call from her cryſtal cave the Naiad-Nymph,
Who hides her fine form in the paſſing lymph, 30
And, as below ſhe braids her hyaline hair,
Eyes her ſoft ſmiles reflected in the air;
Or ſport in groups with River-Boys, that lave
Their ſilken limbs amid the daſhing wave;
Pluck the pale primroſe bending from its edge, 35
Or tittering dance amid the whiſpering ſedge.—

" Onward *you* paſs, the pine-capt hills divide,
Or feed the golden harveſts on their ſide;

---

or reflections ſeen on the ſurface of miſts from high mountains in Ulloa's Voyages. The dry miſt of ſummer 1783, was probably occaſioned by volcanic eruption, as mentioned in note on Chunda, Vol. II. and therefore more like the atmoſphere of ſmoke which hangs on ſtill days over great cities.

There is a dry miſt, or rather a diminiſhed tranſparence of the air, which according to Mr. Sauſſure accompanies fair weather, while great tranſparence of air indicates rain. Thus when large rivers two miles broad, ſuch as at Liverpool, appear narrow, it is ſaid to prognoſticate rain; and when wide, fair weather. This want of tranſparence of the air in dry weather, may be owing to new combinations or decompoſitions of the vapours diſſolved in it, but wants further inveſtigation. Eſſais ſur L'Hygromet, p. 357.

*Round the gelid hill.* l. 20. See additional notes, No. XXVI. on the origin of ſprings.

The wide-ribb'd arch with hurrying torrents fill,
Shove the ſlow barge, or whirl the foaming mill.
*Or* lead with beckoning hand the ſparkling train
Of refluent water to its parent main,
And pleaſed reviſit in their ſea-moſs vales
Blue Nereid-forms array'd in ſhining ſcales,
Shapes, whoſe broad oar the torpid wave impels,
And Tritons bellowing through their twiſted ſhells.

" So from the heart the ſanguine ſtream diſtils,
O'er Beauty's radiant ſhrine in vermil rills,
Feeds each fine nerve, each ſlender hair pervades,
The ſkins bright ſnow with living purple ſhades,
Each dimpling cheek with warmer bluſhes dyes,
Laughs on the lips, and lightens in the eyes.
—Erewhile abſorb'd, the vagrant globules ſwim
From each fair feature, and proportioned limb,
Join'd in one trunk with deeper tint return
To the warm concave of the vital urn.

II. 1. " AQUATIC MAIDS! *you* ſway the mighty realms
Of ſcale and ſhell, which Ocean overwhelms;
As Night's pale Queen her riſing orb reveals,
And climbs the zenith with refulgent wheels,
Car'd on the foam your glimmering legion rides,
Your little tridents heave the daſhing tides,

*Car'd on the foam.* l. 61. The phenomena of the tides have been well inveſtigated and ſatisfactorily explained by Sir Iſaac Newton and Dr. Halley from the reciprocal gravitations of the earth, moon, and ſun. As the earth and moon move round a centre of motion near the earth's ſurface, at the ſame time that they are proceeding in their annual orbit round the ſun, it follows that the water on the ſide of the earth neareſt this centre of motion between the earth and moon will be more attracted by

Urge on the ſounding ſhores their cryſtal courſe,
Reſtrain their fury, or direct their force.

2. " *Nymphs ! you* adorn, in gloſſy volumes roll'd,
The gaudy conch with azure, green, and gold.

the moon, and the waters on the oppoſite ſide of the earth will be leſs attracted by the moon, than the central parts of the earth. Add to this that the centrifugal force of the water on the ſide of the earth furtheſt from the centre of the motion, round which the earth and moon move, (which, as was ſaid before, is near the ſurface of the earth) is greater than that on the oppoſite ſide of the earth. From both theſe cauſes it is eaſy to comprehend that the water will riſe on two ſides of the earth, viz. on that neareſt to the moon, and its oppoſite ſide, and that it will be flattened in conſequence at the quadratures, and thus produce two tides in every lunar day, which conſiſts of about twenty-four hours and forty-eight minutes.

Theſe tides will be alſo affected by the ſolar attraction when it coincides with the lunar one, or oppoſes it, as at new and full moon, and will alſo be much influenced by the oppoſing ſhores in every part of the earth.

Now as the moon in moving round the centre of gravity between itſelf and the earth deſcribes a much larger orbit than the earth deſcribes round the ſame centre, it follows that the centrifugal motion of the ſide of the moon oppoſite to the earth muſt be much greater than the centrifugal motion of the ſide of the earth oppoſite to the moon round the ſame centre. And ſecondly, as the attraction of the earth exerted on the moon's ſurface next to the earth is much greater than the attraction of the moon exerted on the earth's ſurface, the tides on the lunar ſea, (if ſuch there be,) ſhould be much greater than thoſe of our ocean. Add to this that as the ſame face of the moon always is turned to the earth, the lunar tides muſt be permanent, and if the ſolid parts of the moon be ſpherical, muſt always cover the phaſis next to us. But as there are evidently hills and vales and volcanos on this ſide of the moon, the conſequence is that the moon has no ocean, or that it is frozen.

*The gaudy conch*. l. 66. The ſpiral form of many ſhells ſeem to have afforded a more frugal manner of covering the long tail of the fiſh with calcareous armour; ſince a ſingle thin partition between the adjoining circles of the fiſh was ſufficient to defend both ſurfaces, and thus much cretaceous matter is ſaved; and it is probable that from this ſpiral form they are better enabled to feel the vibrations of the element in which they exiſt. See note on Canto IV. l. 162. This cretaceous matter is formed by a mucous ſecretion from the ſkin of the fiſh, as is ſeen in crab-fiſh, and others which annually caſt their ſhells, and is at firſt a ſoft mucous covering, (like that of a hen's egg, when it is laid a day or two too

*You* round Echinus ray his arrowy mail,
Give the keel'd Nautilus his oar and ſail;
Firm to his rock with ſilver cords ſuſpend
The anchor'd Pinna, and his Cancer-friend; 70
With worm-like beard his toothleſs lips array,
And teach the unwieldy Sturgeon to betray.—
Ambuſh'd in weeds, or ſepulcher'd in ſands,
In dread repoſe He waits the ſcaly bands,

ſoon,) and which gradually hardens. This may alſo be ſeen in common ſhell ſnails, if a part of their ſhell be broken it becomes repaired in a ſimilar manner with mucus, which by degrees hardens into ſhell.

It is probable the calculi or ſtones found in other animals may have a ſimilar origin, as they are formed on mucous membranes, as thoſe of the kidney and bladder, chalk-ſtones in the gout, and gall-ſtones; and are probbaly owing to the inflammation of the membrane where they are produced, and vary according to the degree of inflammation of the membrane which forms them, and the kind of mucous which it naturally produces. Thus the ſhelly matter of different ſhell-fiſh differs, from the coarſer kinds which form the ſhells of crabs, to the finer kinds which produces the mother-pearl.

The beautiful colours of ſome ſhells originate from the thinneſs of the laminæ of which they conſiſt, rather than to any colouring matter, as is ſeen in mother-pearl, which reflects different colours according to the obliquity of the light which falls on it. The beautiful priſmatic colours ſeen on the Labrodore ſtone are owing to a ſimilar cauſe, viz. the thinneſs of the liminæ of which it conſiſts, and has probably been formed from mother-pearl ſhells.

It is curious that ſome of the moſt common foſſil ſhells are not now known in their recent ſtate, as the cornua ammonis; and on the contrary, many ſhells which are very plentiful in their recent ſtate, as limpets, ſea-ears, volutes, cowries, are very rarely found foſſil. Da Coſta's Conchology, p. 163. Were all the ammoniæ deſtroyed when the continents were raiſed? Or do ſome genera of animals periſh by the increaſing power of their enemies? Or do they ſtill reſide at inacceſſible depths in the ſea? Or do ſome animals change their forms gradually and become new genera?

*Echinus. Nautilus.* l. 67, 68. See additional notes, No. XXVII.

*Pinna. Cancer.* l. 70. See additional notes, No. XXVII.

*With worm-like beard.* l. 71. See additional notes, No. XXVIII.

Waves in red ſpires the living lures, and draws
The unwary plunderers to his circling jaws,
Eyes with grim joy the twinkling ſhoals beſet,
And claſps the quick inextricable net.
*You* chaſe the warrior Shark, and cumberous Whale,
And guard the Mermaid in her briny vale;
Feed the live petals of her inſect-flowers,
Her ſhell-wrack gardens, and her ſea-fan bowers;
With ores and gems adorn her coral cell,
And drop a pearl in every gaping ſhell.

3. "*Your* myriad trains o'er ſtagnant ocean's tow,
Harneſs'd with goſſamer, the loitering prow;
Or with fine films, ſuſpended o'er the deep,
Of oil effuſive lull the waves to ſleep.

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*Feed the live petals.* l. 82. There is a ſea-inſect deſcribed by Mr. Huges whoſe claws or tentacles being diſpoſed in regular circles and tinged with variety of bright lively colours repreſent the petals of ſome moſt elegantly fringed and radiated flowers as the carnation, marigold, and anemone. Philoſ. Tranſ. Abridg. Vol. IX. p. 110. The Abbe Dicquemarre has further elucidated the hiſtory of the actinia; and obſerved their manner of taking their prey by incloſing it in theſe beautiful rays like a net. Phil. Tranſ. Vol. LXIII. and LXV. and LXVII.

*And drop a pearl.* l. 84. Many are the opinions both of antient and modern writers concerning the production of pearls. Mr. Reaumur thinks they are formed like the hard concretions in many land animals as ſtones of the bladder, gall-ſtones, and bezoar, and hence concludes them to be a diſeaſe of the fiſh, but there ſeems to be a ſtricter analogy between theſe and the calcareous productions found in crab-fiſh called crab's eyes, which are formed near the ſtomach of the animal, and conſtitute a reſervoir of calcareous matter againſt the renovation of the ſhell, at which time they are re-diſſolved and depoſited for that purpoſe. As the internal part of the ſhell of the pearl, oyſter or muſcle, conſiſts of mother-pearl which is a ſimilar material to the pearl, and as the animal has annually occaſion to enlarge his ſhell, there is reaſon to ſuſpect the looſe pearls are ſimilar reſervoirs of the pearly matter for that purpoſe.

*Or with fine films.* l. 87. See additional notes, No. XXIX.

*You* ſtay the flying bark, conceal'd beneath,
Where living rocks of worm-built coral breathe;
Meet fell TEREDO, as he mines the keel
With beaked head, and break his lips of ſteel;
Turn the broad helm, the fluttering canvas urge
From MAELSTROME's fierce innavigable ſurge.
—'Mid the lorn iſles of Norway's ſtormy main,
As ſweeps o'er many a league his eddying train,
Vaſt watery walls in rapid circles ſpin,
And deep-ingulph'd the Demon dwells within;
Springs o'er the fear-froze crew with Harpy-claws,
Down his deep den the whirling veſſel draws;
Churns with his bloody mouth the dread repaſt,
The booming waters murmuring o'er the maſt.

III. "Where with chill frown enormous *Alps* alarms
A thouſand realms, horizon'd in his arms;
While cloudleſs ſuns meridian glories ſhed
From ſkies of ſilver round his hoary head,
Tall rocks of ice refract the coloured rays,
And Froſt ſits throned amid the lambent blaze;

*Where living rocks.* l. 90. The immenſe and dangerous rocks built by the ſwarms of coral inſects which riſe almoſt perpendicularly in the ſouthern ocean like walls are deſcribed in Cook's voyages, a point of one of theſe rocks broke off and ſtuck in the hole which it had made in the bottom of one of his ſhips, which would otherwiſe have periſhed by the admiſſion of water. The numerous lime-ſtone rocks which conſiſt of a congeries of the cells of theſe animals, and which conſtitute a great part of the ſolid earth, ſhew their prodigious multiplication in all ages of the world. Specimens of theſe rocks are to be ſeen in the Lime-works at Linſel near Newport in Shropſhire, in Coal-brook Dale, and in many parts of the Peak of Derbyſhire. The inſect has been well deſcribed by M. Peyſſonnel, Ellis, and others. Phil. Tranſ. Vol. XLVII. L. LII. and LVII.

*Meet fell Teredo.* l. 91. See additional notes, No. XXX.

*Turn the broad helm.* l. 93. See additional notes, No. XXXI.

*Nymphs! your* thin forms pervade his glittering piles,
His roofs of chryſtal, and his glaſſy ailes; 110
Where in cold caves impriſoned Naiads ſleep,
Or chain'd on moſſy couches wake and weep;
Where round dark crags indignant waters bend
Through rifted ice, in ivory veins deſcend,
Seek through unfathom'd ſnows their devious track, 115
Heave the vaſt ſpars, the ribbed granites crack,

*Where round dark crags.* l. 113. See additional notes, No. XXXII.

*Heave the vaſt ſpars.* l. 116. Water in deſcending down elevated ſituations, if the outlet for it below is not ſufficient for its emiſſion, acts with a force equal to the height of the column, as is ſeen in an experimental machine called the philoſophical bellows, in which a few pints of water are made to raiſe many hundred pounds. To this cauſe is to be aſcribed many large promontories of ice being occaſionally thrown down from the glaciers; rocks have likewiſe been thrown from the ſides of mountains by the ſame cauſe, and large portions of earth have been removed many hundred yards from their ſituations at the foot of mountains. On inſpecting the locomotion of about thirty acres of earth with a ſmall houſe near Bilder's Bridge in Shropſhire, about twenty years ago, from the foot of a mountain towards the river, I well remember it bore all the marks of having been thus lifted up, puſhed away, and as it were crumpled into ridges, by a column of water contained in the mountain.

From water being thus confined in high columns between the ſtrata of mountainous countries, it has often happened that when wells or perforations have been made into the earth, that ſprings have ariſen much above the ſurface of the new well. When the new bridge was building at Dublin, Mr. G. Semple found a ſpring in the bed of the river where he meant to lay the foundation of a pierre, which, by fixing iron pipes into it, he raiſed many feet. Treatiſe on Building in Water, by G. Semple. From having obſerved a valley north-weſt of St. Alkmond's well near Derby, at the head of which that ſpring of water once probably exiſted, and by its current formed the valley, (but which in after times found its way out in its preſent ſituation,) I ſuſpect that St. Alkmond's well might by building round it be raiſed high enough to ſupply many ſtreets in Derby with ſpring-water which are now only ſupplied with river-water. See an account of an artificial ſpring of water, Phil. Tranſ. Vol. LXXV. p. 1.

In making a well at Sheerneſs the water roſe 300 feet above its ſource in the well. Phil. Tranſ. Vol. LXXIV. And at Hartford in Connecticut

Ruſh into day, in foamy torrents ſhine,
And ſwell the imperial Danube or the Rhine.—
—Or feed the murmuring TIBER, as he laves
His realms inglorious with diminiſh'd waves,
Hears his lorn Forum ſound with Eunuch-ſtrains,
Sees dancing ſlaves inſult his martial plains;
Parts with chill ſtream the dim religious bower,
Time-mouldered baſtion, and diſmantled tower;
By alter'd fanes and nameleſs villas glides,
And claſſic domes, that tremble on his ſides;
Sighs o'er each broken urn, and yawning tomb,
And mourns the fall of *Liberty* and ROME.

IV. "Sailing in air, when dark *Monſoon* inſhrouds
His tropic mountains in a night of clouds;

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there is a well which was dug ſeventy feet deep before water was found, then in boring an augur-hole through a rock the water roſe ſo faſt as to make it difficult to keep it dry by pumps till they could blow the hole larger by gunpowder, which was no ſooner accompliſhed than it filled and run over, and has been a brook for near a century. Travels through America. Lond. 1789. Lane.

*Dark monſoon inſhrouds.* l. 129. When from any peculiar ſituations of land in reſpect to the ſea the tropic becomes more heated, when the ſun is vertical over it, than the line, the periodical winds called monſoons are produced, and theſe are attended by rainy ſeaſons; for as the air at the tropic is now more heated than at the line it aſcends by decreaſe of its ſpecific gravity, and floods of air ruſh in both from the South Weſt and North Eaſt, and theſe being one warmer than the other the rain is precipitated by their mixture as obſerved by Dr. Hutton. See additional notes, No. XXV. All late travellers have aſcribed the riſe of the Nile to the monſoons which deluge Nubia and Abyſſinia with rain. The whirling of the aſcending air was even ſeen by Mr. Bruce in Abyſſinia; he ſays, "every morning a ſmall cloud began to whirl round, and pre-" ſently after the whole heavens became covered with clouds," by this vortex of aſcending air the N. E. winds and the S. W. winds, which flow in to ſupply the place of the aſcending column, became mixed more rapidly and depoſited their rain in greater abundance.

Or drawn by whirlwinds from the Line returns,
And ſhowers o'er Afric all his thouſand urns;
High o'er his head the beams of SIRIUS glow,
And, Dog of Nile, ANUBIS barks below.
*Nymphs! you* from cliff to cliff attendant guide 135
In headlong cataracts the impetuous tide;
Or lead o'er waſtes of Abyſſinian ſands
The bright expanſe to EGYPT's ſhower-leſs lands.
—Her long canals the ſacred waters fill,
And edge with ſilver every peopled hill; 140
Gigantic SPHINX in circling waves admire,
And MEMNON bending o'er his broken lyre;

Mr. Volney obſerves that the time of the riſing of the Nile commences about the 19th of June, and that Abyſſinia and the adjacent parts of Africa are deluged with rain in May, June, and July, and produce a maſs of water which is three months in draining off. The Abbe Le Pluche obſerves that as Sirius, or the dog-ſtar, roſe at the time of the commencement of the flood its riſing was watched by the aſtronomers, and notice given of the approach of inundation by hanging the figure of Anubis, which was that of a man with a dog's head, upon all their temples. Hiſtoire de Ciel.

*Egypt ſhower-leſs lands.* l. 138. There ſeem to be two ſituations which may be conceived to be exempted from rain falling upon them, one where the conſtant trade-winds meet beneath the line, for here two regions of warm air are mixed together, and thence do not ſeem to have any cauſe to precipitate their vapour; and the other is, where the winds are brought from colder climates and become warmer by their contact with the earth of a warmer one. Thus Lower Egypt is a flat country warmed by the ſun more than the higher lands of one ſide of it, and than the Mediterranean on the other; and hence the winds which blow over it acquire greater warmth, which ever way they come, than they poſſeſſed before, and in conſequence have a tendency to acquire and not to part with their vapour like the north-eaſt winds of this country. There is ſaid to be a narrow ſpot upon the coaſt of Peru where rain ſeldom occurs, at the ſame time according to Ulloa on the mountainous regions of the Andes beyond there is almoſt perpetual rain. For the wind blows uniformly upon this hot part of the coaſt of Peru, but no cauſe of devaporation occurs till it begins to aſcend the mountainous Andes, and then its own expanſion produces cold ſufficient to condenſe its vapour.

O'er furrow'd glebes and green ſavannas ſweep,
And towns and temples laugh amid the deep.

V. 1. "High in the frozen North where HECCLA glows,
And melts in torrents his coeval ſnows;
O'er iſles and oceans ſheds a ſanguine light,
Or ſhoots red ſtars amid the ebon night;
When, at his baſe intomb'd, with bellowing ſound
Fell GIESAR roar'd, and ſtruggling ſhook the ground;
Pour'd from red noſtrils, with her ſcalding breath,
A boiling deluge o'er the blaſted heath;
And, wide in air, in miſty volumes hurl'd
Contagious atoms o'er the alarmed world;
*Nymphs! your* bold myriads broke the infernal ſpell,
And cruſh'd the Sorcereſs in her flinty cell.

2. "Where with ſoft fires in unextinguiſh'd urns,
Cauldron'd in rock, innocuous Lava burns;
On the bright lake *your* gelid hands diſtil
In pearly ſhowers the parſimonious rill;

*Fell Gieſar roar'd.* l. 150. The boiling column of water at Gieſar in Iceland was nineteen feet in diameter, and ſometimes roſe to the height of ninety-two feet. On cooling it depoſited a ſiliceous matter or chalcedony forming a baſon round its baſe. The heat of this water before it roſe out of the earth could not be aſcertained, as water loſes all its heat above 212 (as ſoon as it is at liberty to expand) by the exhalation of a part, but the flinty baſon which is depoſited from it ſhews that water with great degrees of heat will diſſolve ſiliceous matter. Van Troil's Letters on Iceland. Since the above account in the year 1780 this part of Iceland has been deſtroyed by an earthquake or covered with lava, which was probably effected by the force of aqueous ſteam, a greater quantity of water falling on the ſubterraneous fires than could eſcape by the antient outlets and generating an increaſed quantity of vapour. For the diſperſion of contagious vapours from volcanos ſee an account of the Harmattan in the notes on Chunda, Vol. II.

And, as aloft the curling vapours riſe
Through the cleft roof, ambitious for the ſkies,
In vaulted hills condenſe the tepid ſteams,
And pour to *Health* the medicated ſtreams.
—So in green vales amid her mountains bleak
BUXTONIA ſmiles, the Goddeſs-Nymph of Peak;
Deep in warm waves, and pebbly baths ſhe dwells,
And calls HYGEIA to her ſainted wells.

"Hither in ſportive bands bright DEVON leads
Graces and Love from Chatſworth's flowery meads.—
Charm'd round the *Nymph*, they climb the rifted rocks;
And ſteep in mountain-miſt their golden locks;
On venturous ſtep her ſparry caves explore,
And light with radiant eyes her realms of ore;
—Oft by her bubbling founts, and ſhadowy domes,
In gay undreſs the fairy legion roams,
Their dripping palms in playful malice fill,
Or taſte with ruby lip the ſparkling rill;
Croud round her baths, and, bending o'er the ſide,
Unclaſp'd their ſandals, and their zones untied,
Dip with gay fear the ſhuddering foot undreſs'd,
And quick retract it to the fringed veſt;
Or cleave with brandiſh'd arms the lucid ſtream,
And ſob, their blue eyes twinkling in the ſteam.

*Buxtonia ſmiles*. l. 166. Some arguments are mentioned in the note on Fucus Vol. II. to ſhew that the warm ſprings of this country do not ariſe from the decompoſition of pyrites near the ſurface of the earth, but that they are produced by ſteam riſing up the fiſſures of the mountains from great depths, owing to water falling on ſubterraneous fires, and that this ſteam is condenſed between the ſtrata of the incumbent mountains and collected into ſprings. For further proofs on this ſubject the reader is referred to a Letter from Dr. Darwin in Mr. Pilkington's View of Derbyſhire, Vol. I. p. 256.

*And ſob, their blue eyes*. l. 184. The bath at Buxton being of 82 degrees of heat is called a warm bath, and is ſo compared with common

—High o'er the chequer'd vault with tranſient glow
Bright luſtres dart, as daſh the waves below;
And Echo's ſweet reſponſive voice prolongs
The dulcet tumult of their ſilver tongues.—
O'er their fluſh'd cheeks uncurling treſſes flow,
And dew-drops glitter on their necks of ſnow;
Round each fair Nymph her dropping mantle clings,
And Loves emerging ſhake their ſhowery wings.

"Here oft her **Lord** ſurveys the rude domain,
Fair arts of Greece triumphant in his train;
Lo! as he ſteps, the column'd pile aſcends,
The blue roof cloſes, or the creſcent bends;

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ſpring-water which poſſeſſes but 48 degrees of heat, but is nevertheleſs a cold bath compared to the heat of the body which is 98. On going into this bath there is therefore always a chill perceived at the firſt immerſion, but after having been in it a minute the chill ceaſes and a ſenſation of warmth ſucceeds though the body continues to be immerſed in the water. The cauſe of this curious phenomenon is to be looked for in the laws of animal ſenſation and not from any properties of heat. When a perſon goes from clear day-light into an obſcure room for a while it appears gloomy, which gloom however in a little time ceaſes, and the deficiency of light becomes no longer perceived. This is not ſolely owing to the enlargement of the iris of the eye, ſince that is performed in an inſtant, but to this law of ſenſation, that when a leſs ſtimulus is applied (within certain bounds) the ſenſibility increaſes. Thus at going into a bath as much colder than the body as that of Buxton, the diminution of heat on the ſkin is at firſt perceived, but in about a minute the ſenſibility to heat increaſes and the nerves of the ſkin are equally excited by the leſſened ſtimulus. The ſenſation of warmth at emerging from a cold-bath, and the pain called the hot-ach, after the hands have been immerſed in ſnow, depend on the ſame principle, viz. the increaſed ſenſibility of the ſkin after having been previouſly expoſed to a ſtimulus leſs than uſual.

*Here oft her Lord.* l. 193. Alluding to the magnificent and beautiful creſcent, and ſuperb ſtables lately erected at Buxton for the accommodation of the company by the Duke of Devonſhire; and to the plantations with which he has decorated the ſurrounding mountains.

New woods aſpiring clothe their hills with green,
Smooth ſlope the lawns, the grey rock peeps between ;
Relenting Nature gives her hand to Taſte,
And Health and Beauty crown the laughing waſte. 200

VI. " *Nymphs ! your* bright ſquadrons watch with chemic eyes
The cold-elaſtic vapours, as they riſe ;
With playful force arreſt them as they paſs,
And to *pure Air* betroth the *flaming Gas*.
Round their tranſlucent forms at once they fling 205
Their rapturous arms, with ſilver boſoms cling ;
In fleecy clouds their fluttering wings extend,
Or from the ſkies in lucid ſhowers deſcend ;
Whence rills and rivers owe their ſecret birth,
And Ocean's hundred arms infold the earth. 210

*And to pure air.* l. 204. Until very lately water was eſteemed a ſimple element, nor are all the moſt celebrated chemiſts of Europe yet converts to the new opinion of its decompoſition. Mr. Lavoiſier and others of the French ſchool have moſt ingeniouſly endeavoured to ſhew that water conſiſts of pure air, called by them oxygene, and of inflammable air, called hydrogene, with as much of the matter of heat, or calorique, as is neceſſary to preſerve them in the form of gas. Gas is diſtinguiſhed from ſteam by its preſerving its elaſticity under the preſſure of the atmoſphere, and in the greateſt degrees of cold yet known. The hiſtory of the progreſs of this great diſcovery is detailed in the Memoires of the Royal Academy for 1781, and the experimental proofs of it are delivered in Lavoiſier's Elements of Chemiſtry. The reſults of which are that water conſiſts of eighty-five parts by weight of oxygene, and fifteen parts by weight of hydrogene, with a ſufficient quantity of Calorique. Not only numerous chemical phenomena, but many atmoſpherical and vegetable facts receive clear and beautiful elucidation from this important analyſis. In the atmoſphere inflammable air is probably perpetually uniting with vital air and producing moiſture which deſcends in dews and ſhowers, while the growth of vegetables by the aſſiſtance of light is perpetually again decompoſing the water they imbibe from the earth, and while they retain the inflammable air for the formation of oils, wax, honey, reſin, &c. they give up the vital air to repleniſh the atmoſphere.

"So, robed by Beauty's Queen, with ſofter charms
SATURNIA woo'd the Thunderer to her arms;
O'er her fair limbs a veil of light ſhe ſpread,
And bound a ſtarry diadem on her head;
Long braids of pearl her golden treſſes grac'd,
And the charm'd CESTUS ſparkled round her waiſt.
—Raiſed o'er the woof, by Beauty's hand inwrought,
Breathes the ſoft Sigh, and glows the enamour'd Thought;
Vows on light wings ſucceed, and quiver'd Wiles,
Aſſuaſive Accents, and ſeductive Smiles.
—Slow rolls the Cyprian car in purple pride,
And, ſteer'd by LOVE, aſcends admiring Ide;
Climbs the green ſlopes, the nodding woods pervades,
Burns round the rocks, or gleams amid the ſhades.—
Glad ZEPHYR leads the train, and waves above
The barbed darts, and blazing torch of Love;
Reverts his ſmiling face, and pauſing flings
Soft ſhowers of roſes from aurelian wings.
Delighted Fawns, in wreathes of flowers array'd,
With tiptoe Wood-Boys beat the chequer'd glade;
Alarmed Naiads, riſing into air,
Lift o'er their ſilver urns their leafy hair;
Each to her oak the baſhful Dryads ſhrink,
And azure eyes are ſeen through every chink.
—LOVE culls a flaming ſhaft of broadeſt wing,
And reſts the fork upon the quivering ſtring;
Points his arch eye aloft, with fingers ſtrong
Draws to his curled ear the ſilken thong;

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*And ſteer'd by love.* l. 222. The younger love, or Cupid, the ſon of Venus, owes his exiſtence and his attributes to much later times than the Eros, or divine love, mentioned in Canto I. ſince the former is no where mentioned by Homer, though ſo many apt opportunities of introducing him occur in the works of that immortal bard. Bacon.

Loud twangs the ſteel, the golden arrow flies,
Trails a long line of luſtre through the ſkies;
"'Tis done!" he ſhouts, "the mighty Monarch feels!"
And with loud laughter ſhakes the ſilver wheels;
Bends o'er the car, and whirling, as it moves,
His looſen'd bowſtring, drives the riſing doves.
—Pierced on his throne the ſtarting Thunderer turns,
Melts with ſoft ſighs, with kindling rapture burns;
Claſps her fair hand, and eyes in fond amaze
The bright Intruder with enamour'd gaze.
"And leaves my Goddeſs, like a blooming bride,
"The fanes of Argos for the rocks of Ide?
"Her gorgeous palaces, and amaranth bowers,
"For cliff-top'd mountains, and aerial towers?"
He ſaid; and, leading from her ivory ſeat
The bluſhing Beauty to his lone retreat,
Curtain'd with night the couch imperial ſhrouds,
And reſts the crimſon cuſhions upon clouds.—
Earth feels the grateful influence from above,
Sighs the ſoft Air, and Ocean murmurs love;
Etherial Warmth expands his brooding wing,
And in ſtill ſhowers deſcends the genial Spring.

*And in ſtill ſhowers.* l. 260. The allegorical interpretation of the very antient mythology which ſuppoſes Jupiter to repreſent the ſuperior part of the atmoſphere or ether, and Juno the inferior air, and that the conjunction of theſe two produces vernal ſhowers, as alluded to in Virgil's Georgics, is ſo analogous to the preſent important diſcovery of the production of water from pure air, or oxygene, and inflammable air, or hydrogene, (which from its greater levity probably reſides over the former,) that one ſhould be tempted to believe that the very antient chemiſts of Egypt had diſcovered the compoſition of water, and thus repreſented it in their hieroglyphic figures before the invention of letters.

In the paſſage of Virgil Jupiter is called ether, and deſcends in prolific ſhowers on the boſom of Juno, whence the ſpring ſucceeds and all nature rejoices.

VII. " *Nymphs of aquatic Taſte !* whoſe placid ſmile
Breathes ſweet enchantment o'er BRITANNIA's iſle ;
Whoſe ſportive touch in ſhowers reſplendent flings
Her lucid cataracts, and her bubbling ſprings ;
Through peopled vales the liquid ſilver guides,
And ſwells in bright expanſe her freighted tides.
*You* with nice ear, in tiptoe trains, pervade
Dim walks of morn or evening's ſilent ſhade ;
Join the lone Nightingale, her woods among,
And roll your rills ſymphonious to her ſong ;
Through fount-full dells, and wave-worn valleys move,
And tune their echoing waterfalls to love ;
Or catch, attentive to the diſtant roar,
The pauſing murmurs of the daſhing ſhore ;
Or, as aloud ſhe pours her liquid ſtrain,
Purſue the NEREID on the twilight main.
—Her playful Sea-horſe woos her ſoft commands,
Turns his quick ears, his webbed claws expands,
His watery way with waving volutes wins,
Or liſtening librates on unmoving fins.
The Nymph emerging mounts her ſcaly ſeat,
Hangs o'er his gloſſy ſides her ſilver feet,
With ſnow-white hands her arching veil detains,
Gives to his ſlimy lips the ſlacken'd reins,
Lifts to the ſtar of Eve her eye ſerene,
And chaunts the birth of Beauty's radiant Queen.—
O'er her fair brow her pearly comb unfurls,
Her beryl locks, and parts the waving curls,

Tum pater omnipotens fœcundis imbribus Æther
Conjugis in gremium lætæ deſcendit, et omnes
Magnus alit, magno commixtus corpore, fætus.
Virg. Georg. Lib. II. l. 325.

*Her playful ſeahorſe.* l. 277. Deſcribed from an antique gem.

Each tangled braid with gliſtening teeth unbinds
And with the floating treaſure muſks the winds.—
Thrill'd by the dulcet accents, as ſhe ſings,
The rippling wave in widening circles rings;
Night's ſhadowy forms along the margin gleam
With pointed ears or dance upon the ſtream;
The Moon tranſported ſtays her bright career,
And maddening Stars ſhoot headlong from the ſphere.

VIII. " *Nymphs!* whoſe fair eyes with vivid luſtres glow
For human weal, and melt at human woe;
Late as *you* floated on your ſilver ſhells,
Sorrowing and ſlow by DERWENT's willowy dells;
Where by tall groves his foamy flood he ſteers
Through ponderous arches o'er impetuous wears,
By DERBY's ſhadowy towers reflective ſweeps,
And gothic grandeur chills his duſky deeps;
*You* pearl'd with Pity's drops his velvet ſides,
Sigh'd in his gales, and murmur'd in his tides,
Waved o'er his fringed brink a deeper gloom,
And bow'd his alders o'er MILCENA's tomb.

" Oft with ſweet voice She led her infant-train,
Printing with graceful ſtep his ſpangled plain,
Explored his twinkling ſwarms, that ſwim or fly,
And mark'd his florets with botanic eye.—
" Sweet bud of Spring! how frail thy tranſient bloom,
" Fine film," ſhe cried, " of Nature's faireſt loom!
" Soon Beauty fades upon its damaſk throne!"—
—Unconſcious of the worm, that mined her own!—

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*O'er Milcena's tomb.* l. 308. In memory of Mrs. French, a lady who to many other elegant accompliſhments added a proficiency in botany and natural hiſtory.

—Pale are thoſe lips, where ſoft careſſes hung,
Wan the warm cheek, and mute the tender tongue,
Cold reſts that feeling heart on Derwent's ſhore,
And thoſe love-lighted eye-balls roll no more!

IX. "*Your* virgin trains on BRINDLEY's cradle ſmiled,
And nurſed with fairy-love the unletter'd child,
Spread round his pillow all your ſecret ſpells,
Pierced all your ſprings, and open'd all your wells.—
As now on graſs, with gloſſy folds reveal'd,
Glides the bright ſerpent, now in flowers conceal'd;
Far ſhine the ſcales, that gild his ſinuous back,
And lucid undulations mark his track;
So with ſtrong arm immortal BRINDLEY leads
His long canals, and parts the velvet meads;
Winding in lucid lines, the watery maſs
Mines the firm rock, or loads the deep moraſs,
With riſing locks a thouſand hills alarms,
Flings o'er a thouſand ſtreams its ſilver arms,
Feeds the long vale, the nodding woodland laves,
And Plenty, Arts, and Commerce freight the waves.
—*Nymphs!* who erewhile round BRINDLEY's early bier
On ſnow-white boſoms ſhower'd the inceſſant tear,
Adorn his tomb!—oh, raiſe the marble buſt,
Proclaim his honours, and protect his duſt!
With urns inverted, round the ſacred ſhrine
Their ozier wreaths let weeping Naiads twine;

*On Brindley's cradle ſmiled.* l. 321. The life of Mr. Brindley, whoſe great abilities in the conſtruction of canal navigation were called forth by the patronage of the Duke of Bridgewater, may be read in Dr. Kippis's Biographia Britannica, the excellence of his genius is viſible in every part of this iſland. He died at Turnhurſt in Staffordſhire in 1772, and ought to have a monument in the cathedral church at Lichfield.

While on the top MECHANIC GENIUS ſtands,
Counts the fleet waves, and balances the lands.

X. " *Nymphs! you* firſt taught to pierce the ſecret caves
Of humid earth, and lift her ponderous waves;
Bade with quick ſtroke the ſliding piſton bear
The viewleſs columns of incumbent air;—
Preſs'd by the incumbent air the floods below,
Through opening valves in foaming torrents flow,
Foot after foot with leſſen'd impulſe move,
And riſing ſeek the vacancy above.—
So when the Mother, bending o'er his charms,
Claſps her fair nurſeling in delighted arms;
Throws the thin kerchief from her neck of ſnow,
And half unveils the pearly orbs below;
With ſparkling eye the blameleſs Plunderer owns
Her ſoft embraces, and endearing tones,
Seeks the ſalubrious fount with opening lips,
Spreads his inquiring hands, and ſmiles, and ſips.

" *Connubial Fair!* whom no fond tranſport warms
To lull your infant in maternal arms;

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*Lift her ponderous waves.* l. 346. The invention of the pump is of very antient date, being aſcribed to one Cteſebes an Athenian, whence it was called by the Latins machina Cteſebiana; but it was long before it was known that the aſcent of the piſton lifted the ſuperincumbent column of the atmoſphere, and that then the preſſure of the ſurrounding air on the ſurface of the well below forced the water up into the vacuum, and that on that account in the common lifting pump the water would riſe only about thirty-five feet, as the weight of ſuch a column of water was in general an equipoiſe to the ſurrounding atmoſphere. The foamy appearance of water, when the preſſure of the air over it is diminiſhed, is owing to the expanſion and eſcape of the air previouſly diſſolved by it, or exiſting in its pores. When a child firſt ſucks it only preſſes or champs the teat, as obſerved by the great Harvey, but afterwards it learns to make an incipient vacuum in its mouth, and acts by removing the preſſure of the atmoſphere from the nipple, like a pump.

Who, bleſs'd in vain with tumid boſoms, hear
His tender wailings with unfeeling ear;
The ſoothing kiſs and milky rill deny
To the ſweet pouting lip, and gliſtening eye!—
Ah! what avails the cradle's damaſk roof,
The eider bolſter, and embroider'd woof!—
Oft hears the gilded couch unpity'd plains,
And many a tear the taſſel'd cuſhion ſtains!
No voice ſo ſweet attunes his cares to reſt,
So ſoft no pillow, as his mother's breaſt!—
—Thus charm'd to ſweet repoſe, when twilight hours
Shed their ſoft influence on celeſtial bowers,
The Cherub, Innocence, with ſmile divine
Shuts his white wings, and ſleeps on Beauty's ſhrine.

XI. "From dome to dome when flames infuriate climb,
Sweep the long ſtreet, inveſt the tower ſublime;
Gild the tall vanes amid the aſtoniſh'd night,
And reddening heaven returns the ſanguine light;
While with vaſt ſtrides and briſtling hair aloof
Pale Danger glides along the falling roof;
And Giant Terror howling in amaze
Moves his dark limbs acroſs the lurid blaze.
*Nymphs! you* firſt taught the gelid wave to riſe,
Hurl'd in reſplendent arches to the ſkies;
In iron cells condenſed the airy ſpring,
And imp'd the torrent with unfailing wing;

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*Ah! what avails*. l. 367. From an elegant little poem of Mr. Jerningham's intitled Il Latte, exhorting ladies to nurſe their own children.

*Hurl'd in reſplendent arches*. l. 386. The addition of an air-cell to machines for raiſing water to extinguiſh fire was firſt introduced by Mr. Newſham of London, and is now applied to ſimilar engines for waſhing

—On the fierce flames the ſhower impetuous falls,
And ſudden darkneſs ſhrouds the ſhatter'd walls;
Steam, ſmoak, and duſt in blended volumes roll,
And Night and Silence repoſſeſs the Pole.—

"Where were ye, *Nymphs!* in thoſe diſaſterous hours,
Which wrap'd in flames AUGUSTA's ſinking towers?
Why did ye linger in your wells and groves,
When ſad WOODMASON mourn'd her infant loves?
When thy fair Daughters with unheeded ſcreams,
Ill-fated MOLESWORTH! call'd the loitering ſtreams?—
The trembling Nymph on bloodleſs fingers hung
Eyes from the tottering wall the diſtant throng,
With ceaſeleſs ſhrieks her ſleeping friends alarms,
Drops with ſinged hair into her lover's arms.—
The illumin'd Mother ſeeks with footſteps fleet,
Where hangs the ſafe balcony o'er the ſtreet,
Wrap'd in her ſheet her youngeſt hope ſuſpends,
And panting lowers it to her tiptoe friends;

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wall-trees in gardens, and to all kinds of forcing pumps, and might be applied with advantage to liſting pumps where the water is brought from a great diſtance horizontally. Another kind of machine was invented by one Greyl, in which a veſſel of water was every way diſperſed by the exploſion of gun-powder lodging in the centre of it, and lighted by an adapted match; from this idea Mr. Godfrey propoſed a water-bomb of ſimilar conſtruction. Dr. Hales to prevent the ſpreading of fire propoſed to cover the floors and ſtairs of the adjoining houſes with earth; Mr. Hartley propoſed to prevent houſes from taking fire by covering the cieling with thin iron plates, and Lord Mahon by a bed of coarſe mortar or plaiſter between the cieling and floor above it. May not this age of chemical ſcience diſcover ſome method of injecting or ſoaking timber with lime-water and afterwards with vitriolic acid, and thus fill its pores with alabaſter? or of penetrating it with ſiliceous matter, by proceſſes ſimilar to thoſe of Bergman and Achard? See Cronſtadt's Mineral. 2d. edit. Vol. I. p. 222.

*Woodmaſon, Moleſworth.* l. 396. The hiſtories of theſe unfortunate families may be ſeen in the Annual Regiſter, or in the Gentleman's Magazine.

Again ſhe hurries on affection's wings,
And now a third ; and won a fourth, ſhe brings ;
Safe all her babes, ſhe ſmooths her horrent brow,
And burſts through bickering flames, unſcorch'd, below.
So, by her Son arraign'd, with feet unſhod
O'er burning bars indignant Emma trod.

" E'en on the day when Youth with Beauty wed,
The flames ſurprized them in their nuptial bed ;—
Seen at the opening ſaſh with boſom bare,
With wringing hands, and dark diſhevel'd hair,
The bluſhing Beauty with diſorder'd charms
Round her fond lover winds her ivory arms ;
Beat, as they claſp, their throbbing hearts with fear,
And many a kiſs is mix'd with many a tear ;—
Ah me ! in vain the labouring engines pour
Round their pale limbs the ineffectual ſhower !—
—Then craſh'd the floor, while ſhrinking crouds retire,
And Love and Virtue ſunk amid the fire !—
With piercing ſcreams afflicted ſtrangers mourn,
And their white aſhes mingle in their urn.

XII. " *Pellucid Forms !* whoſe cryſtal boſoms ſhow
The ſhine of welfare, or the ſhade of woe !
Who with ſoft lips ſalute returning Spring,
And hail the Zephyr quivering on his wing ;
Or watch, untired, the wintery clouds, and ſhare
With ſtreaming eyes my vegetable care ;
Go, ſhove the dim miſt from the mountain's brow,
Chaſe the white fog, which floods the vale below ;

*Shove the dim miſt.* l. 433. See note on l. 20 of this Canto.

*Catch the hail-ſtones.* l. 436. See note on l. 15 of this Canto.

Melt the thick ſnows, that linger on the lands, 435
And catch the hailſtones in your little hands;
Guard the coy bloſſom from the pelting ſhower,
And daſh the rimy ſpangles from the bower;
From each chill leaf the ſilvery drops repel,
And cloſe the timorous floret's golden bell. 440

*From each chill leaf.* l. 439. The upper ſide of the leaf is the organ of vegetable reſpiration, as explained in the additional notes, No XXXVII, hence the leaf is liable to injury from much moiſture on this ſurface, and is deſtroyed by being ſmeared with oil, in theſe reſpects reſembling the lungs of animals or the ſpiracula of inſects. To prevent theſe injuries ſome leaves repel the dew-drops from their upper ſurfaces as thoſe of cabbages; other vegetables cloſe the upper ſurfaces of their leaves together in the night or in wet weather, as the ſenſitive plant; others only hang their leaves downwards ſo as to ſhoot the wet from them, as kidney-beans, and many trees. See note on l. 18 of this Canto.

*Golden bell.* l. 440. There are muſcles placed about the footſtalks of the leaves or leaflets of many plants, for the purpoſe of cloſing their upper ſurfaces together, or of bending them down ſo as to ſhoot off the ſhowers or dew-drops, as mentioned in the preceding note. The claws of the petals or of the diviſions of the calyx of many flowers are furniſhed in a ſimilar manner with muſcles, which are exerted to open or cloſe the corol and calyx of the flower as in tragopogon, anemone. This action of opening and cloſing the leaves or flowers does not appear to be produced ſimply by *irritation* on the muſcles themſelves, but by the connection of thoſe muſcles with a *ſenſitive* ſenſorium or brain exiſting in each individual bud or flower. 1ſt. Becauſe many flowers cloſe from the defect of ſtimulus, not by the exceſs of it, as by darkneſs, which is the abſence of the ſtimulus of light; or by cold, which is the abſence of the ſtimulus of heat. Now the defect of heat, or the abſence of food, or of drink, affects our *ſenſations*, which had been previouſly accuſtomed to a greater quantity of them; but a muſcle cannot be ſaid to be ſtimulated into action by a defect of ſtimulus. 2. Becauſe the muſcles around the footſtalks of the ſubdiviſions of the leaves of the ſenſitive plant are exerted when any injury is offered to the other extremity of the leaf, and ſome of the ſtamens of the flowers of the claſs Syngeneſia contract themſelves when others are irritated. See note on Chondrilla, Vol. II. of this work.

From this circumſtance the contraction of the muſcles of vegetables ſeems to depend on a diſagreeable *ſenſation* in ſome diſtant part, and not on the *irritation* of the muſcles themſelves. Thus when a particle of duſt ſtimulates the ball of the eye, the eye-lids are inſtantly cloſed, and when

"So ſhould young *Sympathy*, in female form,
Climb the tall rock, ſpectatreſs of the ſtorm;
Life's ſinking wrecks with ſecret ſighs deplore,
And bleed for others' woes, Herſelf on ſhore;
To friendleſs Virtue, gaſping on the ſtrand,
Bare her warm heart, her virgin arms expand,
Charm with kind looks, with tender accents cheer,
And pour the ſweet conſolatory tear;
Grief's cureleſs wounds with lenient balms aſſwage,
Or prop with firmer ſtaff the ſteps of Age;
The lifted arm of mute Deſpair arreſt,
And ſnatch the dagger pointed to his breaſt;
Or lull to ſlumber Envy's haggard mien,
And rob her quiver'd ſhafts with hand unſeen.
—Sound, *Nymphs of* HELICON! the trump of Fame,
And teach Hibernian echoes JONES's name;
Bind round her poliſh'd brow the civic bay,
And drag the fair Philanthropiſt to day.—
So from ſecluded ſprings, and ſecret caves,
Her Liſſy pours his bright meandering waves,
Cools the parch'd vale, the ſultry mead divides,
And towns and temples ſtar his ſhadowy ſides.

XIII. "*Call your* light legions, tread the ſwampy heath,
Pierce with ſharp ſpades the tremulous peat beneath;
With colters bright the ruſhy ſward biſect,
And in new veins the guſhing rills direct;—

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too much light pains the retina, the muſcles of the iris contract its aperture, and this not by any connection or conſent of the nerves of thoſe parts, but as an effort to prevent or to remove a diſagreeable ſenſation, which evinces that vegetables are endued with ſenſation, or that each bud has a common ſenſorium, and is furniſhed with a brain or a central place where its nerves were connected.

*Jones's name.* l. 456. A young lady who devotes a great part of an ample fortune to well choſen acts of ſecret charity.

So flowers ſhall riſe in purple light array'd,
And bloſſom'd orchards ſtretch their ſilver ſhade;
Admiring glebes their amber ears unfold,
And Labour ſleep amid the waving gold. 470

"Thus when young HERCULES with firm diſdain
Braved the ſoft ſmiles of Pleaſure's harlot train;
To valiant toils his forceful limbs aſſign'd,
And gave to Virtue all his mighty mind,
Fierce ACHELOUS ruſh'd from mountain-caves, 475
O'er ſad Etolia pour'd his waſteful waves,
O'er lowing vales and bleating paſtures roll'd,
Swept her red vineyards, and her glebes of gold,
Mined all her towns, uptore her rooted woods,
And Famine danced upon the ſhining floods. 480
The youthful Hero ſeized his curled creſt,
And daſh'd with lifted club the watery Peſt;
With waving arm the billowy tumult quell'd,
And to his courſe the bellowing Fiend repell'd.

"Then to a Snake the finny Demon turn'd 485
His lengthen'd form, with ſcales of ſilver burn'd;
Laſh'd with reſiſtleſs ſweep his dragon-train,
And ſhot meandering o'er the affrighted plain.
The Hero-God, with giant fingers claſp'd
Firm round his neck, the hiſſing monſter graſp'd; 490

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*Fierce Achelous.* l. 475. The river Achelous deluged Etolia, by one of its branches or arms, which in the antient languages are called horns, and produced famine throughout a great tract of country, this was repreſented in hieroglyphic emblems by the winding courſe of a ſerpent and the roaring of a bull with large horns. Hercules, or the emblem of ſtrength, ſtrangled the ſerpent, and tore off one horn from the bull; that is he ſtopped and turned the courſe of one arm of the river, and reſtored plenty to the country. Whence the antient emblem of the horn of plenty Dict. par M. Danet.

With ſtarting eyes, wide throat, and gaping teeth,
Curl his redundant folds, and writhe in death.

"And now a Bull, amid the flying throng
The griſly Demon foam'd, and roar'd along;
With ſilver hoofs the flowery meadows ſpurn'd,
Roll'd his red eye, his threatening antlers turn'd.
Dragg'd down to earth, the Warrior's victor-hands
Preſs'd his deep dewlap on the imprinted ſands;
Then with quick bound his bended knee he ſix'd
High on his neck, the branching horns betwixt,
Strain'd his ſtrong arms, his ſinewy ſhoulders bent,
And from his curled brow the twiſted terror rent.
—Pleaſed Fawns and Nymphs with dancing ſtep applaud,
And hang their chaplets round the reſting God;
Link their ſoft hands, and rear with pauſing toil
The golden trophy on the furrow'd ſoil;
Fill with ripe fruits, with wreathed flowers adorn,
And give to *Plenty* her prolific horn.

XIV. "On Spring's fair lap, *cerulean Siſters!* pour
From airy urns the ſun-illumined ſhower,
Feed with the dulcet drops my tender broods,
Mellifluous flowers, and aromatic buds;
Hang from each bending graſs and horrent thorn
The tremulous pearl, that glitters to the morn;
Or where cold dews their ſecret channels lave,
And Earth's dark chambers hide the ſtagnant wave,
O, pierce, *ye Nymphs!* her marble veins, and lead
Her guſhing fountains to the thirſty mead;

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*Dragg'd down to earth.* l. 497. Deſcribed from an antique gem.

Wide o'er the ſhining vales, and trickling hills
Spread the bright treaſure in a thouſand rills. 520
So ſhall my peopled realms of Leaf and Flower
Exult, inebriate with the genial ſhower;
Dip their long treſſes from the moſſy brink,
With tufted roots the glaſſy currents drink!
Shade your cool manſions from meridian beams, 525
And view their waving honours in your ſtreams.

"Thus where the veins their confluent branches bend,
And milky eddies with the purple blend;
The Chyle's white trunk, diverging from its ſource,
Seeks through the vital maſs its ſhining courſe; 530

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*Spread the bright treaſure.* l. 520. The practice of flooding lands long in uſe in China has been but lately introduced into this country. Beſides the ſupplying water to the herbage in dryer ſeaſons, it ſeems to defend it from froſt in the early part of the year, and thus doubly advances the vegetation. The waters which riſe from ſprings paſſing through marl or limeſtone are replete with calcareous earth, and when thrown over moraſſes they depoſit this earth and incruſt or conſolidate the moraſs. This kind of earth is depoſited in great quantity from the ſprings at Matlock bath, and ſupplies the ſoft porous limeſtone of which the houſes and walls are there conſtructed; and has formed the whole bank for near a mile on that ſide of the Derwent on which they ſtand.

The water of many ſprings contains much azotic gas, or phlogiſtic air, beſides carbonic gas, or fixed air, as that of Buxton and Bath; this being ſet at liberty may more readily contribute to the production of nitre by means of the putreſcent matters which it is expoſed to by being ſpread upon the ſurface of the land; in the ſame manner as frequently turning over heaps of manure facilitates the nitrous proceſs by impriſoning atmoſpheric air in the interſtices of the putreſcent materials. Water ariſing by land-floods brings along with it much of the moſt ſoluble parts of the manure from the higher lands to the lower ones. River-water in its clear ſtate and thoſe ſprings which are called ſoft are leſs beneficial for the purpoſe of watering lands, as they contain leſs earthy or ſaline matter; and water from diſſolving ſnow from its ſlow ſolution brings but little earth along with it, as may be ſeen by the comparative clearneſs of the water of ſnow-floods.

O'er each red cell, and tiſſued membrane ſpreads
In living net-work all its branching threads;
Maze within maze its tortuous path purſues,
Winds into glands, inextricable clues;
Steals through the ſtomach's velvet ſides, and ſips
The ſilver ſurges with a thouſand lips;
Fills each fine pore, pervades each ſlender hair,
And drinks ſalubrious dew-drops from the air.

"Thus when to kneel in Mecca's awful gloom,
Or preſs with pious kiſs Medina's tomb,
League after league, through many a lingering day,
Steer the ſwart Caravans their ſultry way;
O'er ſandy waſtes on gaſping camels toil,
Or print with pilgrim-ſteps the burning ſoil;
If from lone rocks a ſparkling rill deſcend,
O'er the green brink the kneeling nations bend,
Bathe the parch'd lip, and cool the feveriſh tongue,
And the clear lake reflects the mingled throng."

*The Goddeſs pauſed*,—the liſtening bands awhile
Still ſeem to hear, and dwell upon her ſmile;
Then with ſoft murmur ſweep in lucid trains
Down the green ſlopes, and o'er the pebbly plains,
To each bright ſtream on ſilver ſandals glide,
Reflective fountain, and tumultuous tide.

So ſhoot the Spider-broods at breezy dawn
Their glittering net-work o'er the autumnal lawn;
From blade to blade connect with cordage fine
The unbending graſs, and live along the line;
Or bathe unwet their oily forms, and dwell
With feet repulſive on the dimpling well.

So when the North congeals his watery maſs,
Piles high his ſnows, and floors his ſeas with glaſs;
While many a Month, unknown to warmer rays,
Marks its ſlow chronicle by lunar days;
Stout youths and ruddy damſels, ſportive train,
Leave the white ſoil, and ruſh upon the main;
From iſle to iſle the moon-bright ſquadrons ſtray,
And win in eaſy curves their graceful way;
On ſtep alternate borne, with balance nice
Hang o'er the gliding ſteel, and hiſs along the ice.

# ARGUMENT
# OF THE
# FOURTH CANTO.

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# THE
# ECONOMY
# OF
# VEGETATION.

## CANTO IV.

AS when at noon in Hybla's fragrant bowers
CACALIA opens all her honey'd flowers;
Contending ſwarms on bending branches cling,
And nations hover on aurelian wing;
So round the GODDESS, ere ſhe ſpeaks, on high 5
Impatient *Sylphs* in gawdy circlets fly;

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*Cacalia opens.* l. 2. The importance of the nectarium or honey-gland in the vegetable economy is ſeen from the very complicated apparatus, which nature has formed in ſome flowers for the preſervation of their honey from inſects, as in the aconites or monkſhoods; in other plants inſtead of a great apparatus for its protection a greater ſecretion of it is produced that thence a part may be ſpared to the depredation of inſects. The cacalia ſuaveolens produces ſo much honey that on ſome days it may be ſmelt at a great diſtance from the plant. I remember once counting on one of theſe plants beſides bees of various kinds without number, above two hundred painted butterflies, which gave it the beautiful appearance of being covered with additional flowers.

Quivering in air their painted plumes expand,
And coloured ſhadows dance upon the land.

I. " *Sylphs! your* light troops the tropic Winds confine,
And guide their ſtreaming arrows to the Line;
While in warm floods ecliptic breezes riſe,
And ſink with wings benumb'd in colder ſkies.
*You* bid Monſoons on Indian ſeas reſide,
And veer, as moves the ſun, their airy tide;
While ſouthern gales o'er weſtern oceans roll,
And Eurus ſteals his ice-winds from the Pole.
*Your* playful trains, on ſultry iſlands born,
Turn on fantaſtic toe at eve and morn;
With ſoft ſuſurrant voice alternate ſweep
Earth's green pavilions and encircling deep.
*Or* in itinerant cohorts, borne ſublime
On tides of ether, float from clime to clime;
O'er waving Autumn bend your airy ring,
Or waft the fragrant boſom of the Spring.

II. " When Morn, eſcorted by the dancing Hours,
O'er the bright plains her dewy luſtre ſhowers;
Till from her ſable chariot Eve ſerene
Drops the dark curtain o'er the brilliant ſcene;
*You* form with chemic hands the airy ſurge,
Mix with broad vans, with ſhadowy tridents urge.
*Sylphs!* from each ſun-bright leaf, that twinkling ſhakes
O'er Earth's green lap, or ſhoots amid her lakes,
Your playful bands with ſimpering lips invite,
And wed the enamour'd OXYGENE to *Light*.—

*The tropic winds*. l. 9. See additional notes, No. XXXIII.

*The enamour'd oxygene*. l. 34. The common air of the atmoſphere appears by the analyſis of Dr. Prieſtley and other philoſophers to conſiſt

Round their white necks with fingers interwove, 35
Cling the ſond Pair with unabating love;
Hand link'd in hand on buoyant ſtep they riſe,
And ſoar and gliſten in unclouded ſkies.
Whence in bright floods the *Vital Air* expands,
And with concentric ſpheres involves the lands; 40
Pervades the ſwarming ſeas, and heaving earths,
Where teeming Nature broods her myriad births;
Fills the fine lungs of all that *breathe* or *bud*,
Warms the new heart, and dyes the guſhing blood;
With Life's firſt ſpark inſpires the organic frame, 45
And, as it waſtes, renews the ſubtile flame.

of about three parts of an elaſtic fluid unfit for reſpiration or combuſtion, called azote by the French ſchool, and about one fourth of pure vital air fit for the ſupport of animal life and of combuſtion, called oxygene. The principal ſource of the azote is probably from the decompoſition of all vegetable and animal matters by putrefaction and combuſtion; the principal ſource of vital air or oxygene is perhaps from the decompoſition of water in the organs of vegetables by means of the ſun's light. The difficulty of injecting vegetable veſſels ſeems to ſhew that their perſpirative pores are much leſs than thoſe of animals, and that the water which conſtitutes their perſpiration is ſo divided at the time of its excluſion that by means of the ſun's light it becomes decompoſed, the inflammable air or hydrogene, which is one of its conſtituent parts, being retained to form the oil, reſin, wax, honey, &c. of the vegetable economy; and the other part, which united with light or heat becomes vital air or oxygene gas, riſes into the atmoſphere and repleniſhes it with the food of life.

Dr. Prieſtley has evinced by very ingenious experiments that the blood gives out phlogiſton, and receives vital air, or oxygene-gas by the lungs. And Dr. Crawford has ſhewn that the blood acquires heat from this vital air in reſpiration. There is however ſtill a ſomething more ſubtil than heat, which muſt be obtained in reſpiration from the vital air, a ſomething which life can not exiſt a few minutes without, which ſeems neceſſary to the vegetable as well as to the animal world, and which as no organized veſſels can confine it, requires perpetually to be renewed. See note on Canto I. l. 407.

" So pure, ſo ſoft, with ſweet attraction ſhone
Fair PSYCHE, kneeling at the ethereal throne;
Won with coy ſmiles the admiring court of Jove,
And warm'd the boſom of unconquer'd *Love*.—
Beneath a moving ſhade of fruits and flowers
Onward they march to *Hymen's* ſacred bowers;
With lifted torch he lights the feſtive train,
Sublime, and leads them in his golden chain;
Joins the fond pair, indulgent to their vows,
And hides with myſtic veil their bluſhing brows.
Round their fair forms their mingling arms they fling,
Meet with warm lip, and claſp with ruſtling wing.—
—Hence plaſtic Nature, as Oblivion whelms
Her fading forms, repeoples all her realms;
Soft Joys diſport on purple plumes unfurl'd,
And Love and Beauty rule the willing world.

III. 1. " *Sylphs! your* bold myriads on the withering heath
Stay the fell SYROC's ſuffocating breath;
Arreſt SIMOOM in his realms of ſand,
The poiſoned javelin balanced in his hand;—

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*Fair Pſyche.* l. 48. Deſcribed from an antient gem on a fine onyx in poſſeſſion of the Duke of Marlborough, of which there is a beautiful print in Bryant's Mythol. Vol. II. p. 392. And from another antient gem of Cupid and Pſyche embracing, of which there is a print in Spence's Polymetis, p. 82.

*Repeoples all her realms.* l. 60.

> Quæ mare navigerum et terras frugiferentes
> Concelebras; per te quoniam genus omne animantum
> Concipitur, viſitque exortum lumina ſolis. Lucret.

*Arreſt Simoom.* l. 65. " At eleven o'clock while we were with great pleaſure contemplating the rugged tops of Chiggre, where we expected

Fierce on blue ſtreams he rides the tainted air,
Points his keen eye, and waves his whiſtling hair;

to ſolace ourſelves with plenty of good water, Idris cried out with a loud voice, "fall upon your faces, for here is the ſimoom!" I ſaw from the S. E. a haze come in colour like the purple part of a rainbow, but not ſo compreſſed or thick; it did not occupy twenty yards in breadth, and was about twelve feet high from the ground. It was a kind of a bluſh upon the air, and it moved very rapidly, for I ſcarce could turn to fall upon the ground with my head to the northward, when I felt the heat of its current plainly upon my face. We all lay flat upon the ground, as if dead, till Idris told us it was blown over. The meteor, or purple haze, which I ſaw was indeed paſſed; but the light air that ſtill blew was of heat to threaten ſuffocation. For my part I found diſtinctly in my breaſt, that I had imbibed a part of it; nor was I free of an aſthmatic ſenſation till I had been ſome months in Italy." Bruce's Travels. Vol. IV. p. 557.

It is difficult to account for the narrow track of this peſtilential wind, which is ſaid not to exceed twenty yards, and for its ſmall elevation of twelve feet. A whirlwind will paſs forwards, and throw down an avenew of trees by its quick revolution as it paſſes, but nothing like a whirling is deſcribed as happening in theſe narrow ſtreams of air, and whirlwinds aſcend to greater heights. There ſeems but one known manner in which this channel of air could be effected, and that is by electricity.

The volcanic origin of theſe winds is mentioned in the note on Chunda in Vol. II. of this work; it muſt here be added, that Profeſſor Vairo at Naples found, that during the eruption of Veſuvius perpendicular iron bars were electric; and others have obſerved ſuffocating damps to attend theſe eruptions. Ferber's Travels in Italy, p. 133. And laſtly, that a current of air attends the paſſage of electric matter, as is ſeen in preſenting an electrized point to the flame of a candle. In Mr. Bruce's account of this ſimoom, it was in its courſe over a quite dry deſert of ſand, (and which was in conſequence unable to conduct an electric ſtream into the earth beneath it,) to ſome moiſt rocks at but a few miles diſtance; and thence would appear to be a ſtream of electricity from a volcano attended with noxious air; and as the bodies of Mr. Bruce and his attendants were inſulated on the ſand, they would not be ſenſible of their increaſed electricity, as it paſſed over them; to which it may be added, that a ſulphurous or ſuffocating ſenſation is ſaid to accompany flaſhes of lightning, and even ſtrong ſparks of artificial electricity. In the above account of the ſimoom, a great redneſs in the air is ſaid to be a certain ſign of its approach, which may be occaſioned by the eruption of flame from a diſtant volcano in theſe extenſive and impenetrable deſerts of ſand. See Note on l. 292 of this Canto.

While, as he turns, the undulating ſoil
Rolls in red waves, and billowy deſerts boil. 70

*You* ſeize TORNADO by his locks of miſt,
Burſt his denſe clouds, his wheeling ſpires untwiſt;
Wide o'er the Weſt when borne on headlong gales,
Dark as meridian night, the Monſter ſails,
Howls high in air, and ſhakes his curled brow, 75
Laſhing with ſerpent-train the waves below,
Whirls his black arm, the forked lightning flings,
And ſhowers a deluge from his demon-wings.

2. " *Sylphs!* with light ſhafts *you* pierce the drowſy
FOG,
That lingering ſlumbers on the ſedge-wove bog, 80
With webbed feet o'er midnight meadows creeps,
Or flings his hairy limbs on ſtagnant deeps.
*You* meet *Contagion* iſſuing from afar,
And daſh the baleful conqueror from his car;
When, Gueſt of *Death!* from charnel vaults he ſteals,
And bathes in human gore his armed wheels. 86

" Thus when the *Plague*, upborne on Belgian air,
Look'd through the miſt and ſhook his clotted hair,
O'er ſhrinking nations ſteer'd malignant clouds,
And rain'd deſtruction on the gaſping crouds. 90

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*Tornado.* l. 71. See additional notes, No. XXXIII.

*On ſtagnant deeps.* l. 82. All contagious miaſmata originate either from animal bodies, as thoſe of the ſmall pox, or from putrid moraſſes; theſe latter produces agues in the colder climates, and malignant fevers in the warmer ones. The volcanic vapours which cauſe epidemic coughs, are to be ranked amongſt poiſons, rather than amongſt the miaſmata, which produce contagious diſeaſes.

The beauteous ÆGLE felt the venom'd dart,
Slow roll'd her eye, and feebly throbb'd her heart;
Each fervid ſigh ſeem'd ſhorter than the laſt,
And ſtarting Friendſhip ſhunn'd her, as ſhe paſs'd.
—With weak unſteady ſtep the fainting Maid
Seeks the cold garden's ſolitary ſhade,
Sinks on the pillowy moſs her drooping head,
And prints with lifeleſs limbs her leafy bed.
—On wings of Love her plighted Swain purſues,
Shades her from winds, and ſhelters her from dews,
Extends on tapering poles the canvas roof,
Spreads o'er the ſtraw-wove matt the flaxen woof,
Sweet buds and bloſſoms on her bolſter ſtrows,
And binds his kerchief round her aching brows;
Sooths with ſoft kiſs, with tender accents charms,
And claſps the bright infection in his arms.—
With pale and languid ſmiles the grateful Fair
Applauds his virtues, and rewards his care;
Mourns with wet cheek her fair companions fled
On timorous ſtep, or numbered with the dead;
Calls to her boſom all its ſcatter'd rays,
And pours on THYRSIS the collected blaze;
Braves the chill night, careſſing and careſs'd,
And folds her Hero-lover to her breaſt.—
Leſs bold, LEANDER at the duſky hour
Eyed, as he ſwam, the far love-lighted tower;
Breaſted with ſtruggling arms the toſſing wave,
And ſunk benighted in the watery grave.

*The beauteous Ægle.* l. 91. When the plague raged in Holland in 1636, a young girl was ſeized with it, had three carbuncles, and was removed to a garden, where her lover who was betrothed to her, attended her as a nurſe, and ſlept with her as his wife. He remained uninfected, and ſhe recovered, and was married to him. The ſtory is related by Vinc. Fabricius in the Miſc. Cur. Ann. II. Obſ. 188.

Leſs bold, TOBIAS claim'd the nuptial bed,
Where ſeven fond Lovers by a Fiend had bled;
And drove, inſtructed by his Angel-Guide,
The enamour'd Demon from the fatal bride.—
—*Sylphs!* while your winnowing pinions fan'd the air,
And ſhed gay viſions o'er the ſleeping pair;
*Love* round their couch effuſed his roſy breath,
And with his keener arrows conquer'd *Death*.

IV. 1. "*You* charm'd, indulgent *Sylphs!* their learned toil,
And crown'd with fame your TORRICEL, and BOYLE;

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*Torricell and Boyle.* l. 128. The preſſure of the atmoſphere was diſcovered by Torricelli, a diſciple of Galileo, who had previouſly found that the air had weight. Dr. Hook and M. Du Hamel aſcribed the invention of the air-pump to Mr. Boyle, who however confeſſes he had ſome hints concerning its conſtruction from De Guerick. The vacancy at the ſummit of the barometer is termed the Torricellian vacuum, and the exhauſted receiver of an air pump the Boylean vacuum, in honour of theſe two philoſophers.

The miſt and deſcending dew which appear at firſt exhauſting the receiver of an air-pump, are explained in the Phil. Tranſ. Vol. LXXVIII. from the cold produced by the expanſion of air. For a thermometer placed in the receiver ſinks ſome degrees, and in a very little time, as ſoon as a ſufficient quantity of heat can be acquired from the ſurrounding bodies, the dew becomes again taken up. See additional notes, No. VII. Mr. Sauſſure obſerved on placing his hygrometer in a receiver of an air-pump, that though on beginning to exhauſt it the air became miſty, and parted with its moiſture, yet the hair of his hygrometer contracted, and the inſtrument pointed to greater dryneſs. This unexpected occurrence is explained by M. Monge (Annales de Chymie, Tom. V.) to depend on the want of the uſual preſſure of the atmoſphere to force the aqueous particles into the pores of the hair; and M. Sauſſure ſuppoſes, that his veſicular vapour requires more time to be rediſſolved, than is neceſſary to dry the hair of his thermometer. Eſſais ſur l'Hygrom. p. 226. but I ſuſpect there is a leſs hypothetical way of underſtanding it; when a colder body is brought into warm and moiſt air, (as a bottle of ſpring-water for inſtance,) a ſteam is quickly collected on its ſurface; the contrary occurs when a warmer body is brought into cold and damp

Taught with ſweet ſmiles, reſponſive to their prayer,
The ſpring and preſſure of the viewleſs air. 130
—How up exhauſted tubes bright currents flow
Of liquid ſilver from the lake below,
Weigh the long column of the incumbent ſkies,
And with the changeful moment fall and riſe.
—How, as in brazen pumps the piſtons move, 135
The membrane-valve ſuſtains the weight above;
Stroke follows ſtroke, the gelid vapour falls,
And miſty dew-drops dim the cryſtal walls;
Rare and more rare expands the fluid thin,
And Silence dwells with Vacancy within.— 140
So in the mighty Void with grim delight
Primeval Silence reign'd with ancient Night.

2. " *Sylphs!* your ſoft voices, whiſpering from the ſkies,
Bade from low earth the bold MONGULFIER riſe;
Outſtretch'd his buoyant ball with airy ſpring, 145
And bore the Sage on levity of wing—
Where were ye, *Sylphs!* when on the ethereal main
Young ROSIERE launch'd, and call'd your aid in vain?

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air, it continues free from dew ſo long as it continues warm; for it warms the atmoſphere around it, and renders it capable of receiving inſtead of parting with moiſture. The moment the air becomes rarefied in the receiver of the air-pump it becomes colder, as appears by the thermometer, and depoſits its vapour; but the hair of Mr. Sauſſure's hygrometer is now warmer than the air in which it is immerſed, and in conſequence becomes dryer than before, by warming the air which immediately ſurrounds it, a part of its moiſture evaporating along with its heat.

*Young Roſiere launch'd*. l. 148. M. Pilatre du Roſiere with a M. Romain roſe in a balloon from Boulogne in June 1785, and after having been about a mile high for about half an hour the balloon took fire, and the two adventurers were daſhed to pieces on their fall to the ground. Mr. Roſiere was a philoſopher of great talents and activity, joined with

Fair mounts the light balloon, by Zephyr driven,
Parts the thin clouds, and ſails along the heaven; 150
Higher and yet higher the expanding bubble flies,
Lights with quick flaſh, and burſts amid the ſkies.—
Headlong He ruſhes through the affrighted air
With limbs diſtorted, and diſhevel'd hair,
Whirls round and round, the flying croud alarms, 155
And *Death* receives him in his ſable arms!—
So erſt with melting wax and looſen'd ſtrings
Sunk hapleſs ICARUS on unfaithful wings;
His ſcatter'd plumage dancèd upon the wave,
And ſorrowing Mermaids deck'd his watery grave; 160
O'er his pale corſe their pearly ſea-flowers ſhed,
And ſtrew'd with crimſon moſs his marble bed;
Struck in their coral towers the pauſing bell,
And wide in ocean toll'd his echoing knell.

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ſuch urbanity and elegance of manners, as conciliated the affections of his acquaintance and rendered his miſfortunes univerſally lamented. Annual Regiſter for 1784 and 1785, p. 329.

*And wide in ocean.* l. 164. Denſer bodies propagate vibration or ſound better than rarer ones; if two ſtones be ſtruck together under the water, they may be heard a mile or two by any one whoſe head is immerſed at that diſtance, according to an experiment of Dr. Franklin. If the ear be applied to one end of a long beam of timber, the ſtroke of a pin at the other end becomes ſenſible; if a poker be ſuſpended in the middle of a garter, each end of which is preſſed againſt the ear, the leaſt percuſſions on the poker give great ſounds. And I am informed by laying the ear on the ground the tread of a horſe may be diſcerned at a great diſtance in the night. The organs of hearing belonging to fiſh are for this reaſon much leſs complicated than of quadrupeds, as the fluid they are immerſed in ſo much better conveys its vibrations. And it is probable that ſome ſhell-fiſh which have twiſted ſhells like the cochlea and ſemicircular canals of the ears of men and quadrupeds may have no appropriated organ for perceiving the vibrations of the element they live in, but may by their ſpiral form be in a manner all ear.

V. " *Sylphs! you*, retiring to ſequeſter'd bowers, 165
Where oft your PRIESTLEY woos your airy powers,

*Where oft your Prieſtley.* l. 166. The fame of Dr. Prieſtley is known in every part of the earth where ſcience has penetrated. His various diſcoveries reſpecting the analyſis of the atmoſphere, and the production of variety of new airs or gaſſes, can only be clearly underſtood by reading his Experiments on Airs, (3 vols. octavo, Johnſon, London.) the following are amongſt his many diſcoveries. 1. The diſcovery of nitrous and dephlogiſticated airs. 2. The exhibition of the acids and alkalies in the form of air. 3. Aſcertaining the purity of reſpirable air by nitrous air. 4. The reſtoration of vitiated air by vegetation. 5. The influence of light to enable vegetables to yield pure air. 6. The converſion by means of light of animal and vegetable ſubſtances, that would otherwiſe become putrid and offenſive, into nouriſhment of vegetables. 7. The uſe of reſpiration by the blood parting with phlogiſton, and imbibing dephlogiſticated air.

The experiments here alluded to are, 1. Concerning the production of nitrous gas from diſſolving iron and many other metals in nitrous acid, which though firſt diſcovered by Dr. Hales (Static. Eſſ. Vol. I. p. 224) was fully inveſtigated, and applied to the important purpoſe of diſtinguiſhing the purity of atmoſpheric air by Dr. Prieſtley. When about two meaſures of common air and one of nitrous gas are mixed together a red efferveſcence takes place, and the two airs occupy about one-fourth leſs ſpace than was previouſly occupied by the common air alone.

2. Concerning the green ſubſtance which grows at the bottom of reſervoirs of water, which Dr. Prieſtley diſcovered to yield much pure air when the ſun ſhone on it. His method of collecting this air is by placing over the green ſubſtance, which he believes to be a vegetable of the genus conſerva, an inverted bell-glaſs previouſly filled with water, which ſubſides as the air ariſes; it has ſince been found that all vegetables give up pure air from their leaves, when the ſun ſhines upon them, but not in the night, which may be owing to the ſleep of the plant.

3. The third refers to the great quantity of pure air contained in the calces of metals. The calces were long known to weigh much more than the metallic bodies before calcination, inſomuch that 100 pounds of lead will produce 112 pounds of minium; the ore of mangaueſe, which is always found near the ſurface of the earth, is replete with pure air, which is now uſed for the purpoſe of bleaching. Other metals when expoſed to the atmoſphere attract the pure air from it, and become calces by its combination, as zinc, lead, iron; and increaſe in weight in proportion to the air, which they imbibe.

On noiſeleſs ſtep or quivering pinion glide,
As ſits the Sage with Science by his ſide;
To his charm'd eye in gay undreſs appear,
Or pour your ſecrets on his raptured ear. 170
How nitrous Gas from iron ingots driven
Drinks with red lips the pureſt breath of heaven:
How, while Conferva from its tender hair
Gives in bright bubbles empyrean air;
The cryſtal floods phlogiſtic ores calcine, 175
And the pure ETHER marries with the MINE.

“ So in Sicilia's ever-blooming ſhade
When playful PROSERPINE from CERES ſtray'd,
Led with unwary ſtep her virgin trains
O'er Etna's ſteeps, and Enna's golden plains; 180
Pluck'd with fair hand the ſilver-bloſſom'd bower,
And purpled mead,—herſelf a fairer flower;
Sudden, unſeen amid the twilight glade,
Ruſh'd gloomy *Dis*, and ſeized the trembling maid.—
Her ſtarting damſels ſprung from moſſy ſeats, 185
Dropp'd from their gauzy laps the gather'd ſweets,
Clung round the ſtruggling Nymph, with piercing cries,
Purſued the chariot, and invoked the ſkies;—
Pleaſed as he graſps her in his iron arms,
Frights with ſoft ſighs, with tender words alarms, 190

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*When playful Proſerpine.* l. 178. The fable of Proſerpine's being ſeized by Pluto as ſhe was gathering flowers, is explained by Lord Bacon to ſignify the combination or marriage of etherial ſpirit with earthly materials. Bacon's Works, Vol. V. p. 470. edit. 4to. Lond. 1778. This alluſion is ſtill more curiouſly exact, from the late diſcovery of pure air being given up from vegetables, and that then in its unmixed ſtate it more readily combines with metallic or inflammable bodies. From theſe fables which were probably taken from antient hieroglyphics there is frequently reaſon to believe that the Egyptians poſſeſſed much chemical knowledge, which for want of alphabetical writing periſhed with their philoſophers.

The wheels deſcending roll'd in ſmoky rings,
Infernal Cupids flapp'd their demon wings;
Earth with deep yawn received the Fair, amaz'd,
And far in Night celeſtial Beauty blaz'd.

VI. "Led by the Sage, Lo! Britain's ſons ſhall guide
Huge *Sea-Balloons* beneath the toſſing tide; 196
The diving caſtles, roof'd with ſpheric glaſs,
Ribb'd with ſtrong oak, and barr'd with bolts of braſs,
Buoy'd with pure air ſhall endleſs tracks purſue,
And PRIESTLEY's hand the vital flood renew.— 200
Then ſhall BRITANNIA rule the wealthy realms,
Which Ocean's wide inſatiate wave o'erwhelms;
Confine in netted bowers his ſcaly flocks,
Part his blue plains, and people all his rocks.

*Led by the Sage.* l. 195. Dr. Prieſtley's diſcovery of the production of pure air from ſuch variety of ſubſtances will probably ſoon be applied to the improvement of the diving bell, as the ſubſtances which contain vital air in immenſe quantities are of little value as manganeſe and minium. See additional notes, No. XXXIII. In every hundred weight of minium there is combined about twelve pounds of pure air, now as ſixty pounds of water are about a cubic foot, and as air is eight hundred times lighter than water, five hundred weight of minium will produce eight hundred cubic feet of air or about ſix thouſand gallons. Now, as this is at leaſt thrice as pure as atmoſpheric air, a gallon of it may be ſuppoſed to ſerve for three minutes reſpiration for one man. At preſent the air can not be ſet at liberty from minium by vitriolic acid without the application of ſome heat, this is however very likely ſoon to be diſcovered, and will then enable adventurers to journey beneath the ocean in large inverted ſhips or diving balloons.

Mr. Boyle relates, that Cornelius Drebelle contrived not only a veſſel to be rowed under water, but alſo a liquor to be carried in that veſſel which would ſupply the want of freſh air. The veſſel was made by order of James I. and carried twelve rowers beſides paſſengers. It was tried in the river Thames, and one of the perſons who was in that ſubmarine voyage told the particulars of the experiments to a perſon who related them to Mr. Boyle. Annual Regiſter for 1774, p. 248.

Deep, in warm waves beneath the Line that roll, 205
Beneath the ſhadowy ice-iſles of the Pole,
Onward, through bright meandering vales, afar,
Obedient Sharks ſhall trail her ſceptered car,
With harneſs'd necks the pearly flood diſturb,
Stretch the ſilk rein, and champ the ſilver curb; 210
Pleaſed round her triumph wondering Tritons play,
And Seamaids hail her on the watery way.
—Oft ſhall ſhe weep beneath the cryſtal waves
O'er ſhipwreck'd lovers weltering in their graves;
Mingling in death the Brave and Good behold 215
With ſlaves to glory, and with ſlaves to gold;
Shrin'd in the deep ſhall DAY and SPALDING mourn,
Each in his treacherous bell, ſepulchral urn!
Oft o'er thy lovely daughters, hapleſs PIERCE! 219
Her ſighs ſhall breathe, her ſorrows dew their hearſe.—

*Day and Spalding mourn.* l. 217. Mr. Day periſhed in a diving bell, or diving boat, of his own conſtruction at Plymouth in June 1774, in which he was to have continued for a wager twelve hours one hundred feet deep in water, and probably periſhed from his not poſſeſſing all the hydroſtatic knowledge that was neceſſary. See note on Ulva, Vol. II. of this work. See Annual Regiſter for 1774. p. 245.

Mr. Spalding was profeſſionally ingenious in the art of conſtructing and managing the diving bell, and had practiſed the buſineſs many years with ſucceſs. He went down accompanied by one of his young men twice to view the wreck of the Imperial Eaſt-Indiaman at the Kiſh bank in Ireland. On deſcending the third time in June, 1783, they remained about an hour under water, and had two barrels of air ſent down to them, but on the ſignals from below not being again repeated, after a certain time, they were drawn up by their aſſiſtants and both found dead in the bell. Annual Regiſter for 1783, p. 206. Theſe two unhappy events may for a time check the ardor of adventurers in traverſing the bottom of the ocean, but it is probable in another half century it may be ſafer to travel under the ocean than over it, ſince Dr. Prieſtley's diſcovery of procuring pure air in ſuch great abundance from the calces of metals.

*Hapleſs Pierce!* l. 219. The Halſewell Eaſt-Indiaman, outward bound, was wrecked off Seacomb in the Iſle of Purbec on the 6th of January,

With brow upturn'd to Heaven, "*We will not part!*"
He cried, and claſp'd them to his aching heart.—
—Daſh'd in dread conflict on the rocky grounds,
Craſh the ſhock'd maſts, the ſtaggering wreck rebounds;
Through gaping ſeams the ruſhing deluge ſwims,
Chills their pale boſoms, bathes their ſhuddering limbs,
Climbs their white ſhoulders, buoys their ſtreaming hair,
And the laſt ſea-ſhriek bellows in the air.—
Each with loud ſobs her tender ſire careſs'd,
And graſping ſtrain'd him cloſer to her breaſt!—
—Stretch'd on one bier they ſleep beneath the brine,
And their white bones with ivory arms intwine!

VII. "*Sylphs of nice ear!* with beating wings *you* guide
The fine vibrations of the aerial tide;
Join in ſweet cadences the meaſured words,
Or ſtretch and modulate the trembling cords.
*You* ſtrung to melody the Grecian lyre,
Breathed the rapt ſong, and fan'd the thought of fire,
Or brought in combinations, deep and clear,
Immortal harmony to HANDEL's ear.—
*You* with ſoft breath attune the vernal gale,
When breezy evening broods the liſtening vale;
Or wake the loud tumultuous ſounds, that dwell
In Echo's many-toned diurnal ſhell.
*You* melt in dulcet chords, when Zephyr rings
The Eolian Harp, and mingle all its ſtrings;

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1786; when Capt. Pierce, the commander, with two young ladies, his daughters, and the greateſt part of the crew and paſſengers periſhed in the ſea. Some of the officers and about ſeventy ſeamen eſcaped with great difficulty on the rocks, but Capt. Pierce finding it was impoſſible to ſave the lives of the young ladies refuſed to quit the ſhip, and periſhed with them.

Or trill in air the ſoft ſymphonious chime,
When rapt CECILIA lifts her eye ſublime,
Swell, as ſhe breathes, her boſom's riſing ſnow,
O'er her white teeth in tuneful accents flow,
Through her fair lips on whiſpering pinions move,
And form the tender ſighs, that kindle love!

"So playful *Love* on Ida's flowery ſides
With ribbon-rein the indignant Lion guides;
Pleaſed on his brinded back the lyre he rings,
And ſhakes delirious rapture from the ſtrings;
Slow as the pauſing Monarch ſtalks along,
Sheaths his retractile claws, and drinks the ſong;
Soft Nymphs on timid ſtep the triumph view,
And liſtening Fawns with beating hoofs purſue;
With pointed ears the alarmed foreſt ſtarts,
And Love and Muſic ſoften ſavage hearts.

VIII. *Sylphs! your* bold hoſts, when Heaven with juſtice dread
Calls the red tempeſt round the guilty head,
Fierce at his nod aſſume vindictive forms,
And launch from airy cars the vollied ſtorms.—
From Aſhur's vales when proud SENACHERIB trod,
Pour'd his ſwoln heart, defied the living GOD,
Urged with inceſſant ſhouts his glittering powers;
And JUDAH ſhook through all her maſſy towers;
Round her ſad altars preſs'd the proſtrate crowd,
Hoſts beat their breaſts, and ſuppliant chieftains bow'd;
Loud ſhrieks of matrons thrill'd the troubled air,
And trembling virgins rent their ſcatter'd hair;

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*Indignant lion guides.* l. 254. Deſcribed from an antient gem, expreſſive of the combined power of love and muſic, in the Muſeum Florent.

High in the midſt the kneeling King adored, 275
Spread the blaſpheming ſcroll before the Lord,
Raiſed his pale hands, and breathed his pauſing ſighs,
And fixed on Heaven his dim imploring eyes,—
" Oh! MIGHTY GOD! amidſt thy Seraph-throng
" Who ſit'ſt ſublime, the Judge of Right and Wrong;
" Thine the wide earth, bright ſun, and ſtarry zone, 281
" That twinkling journey round thy golden throne;
" Thine is the cryſtal ſource of life and light,
" And thine the realms of Death's eternal night.
" Oh, bend thine ear, thy gracious eye incline, 285
" Lo! Aſhur's King blaſphemes thy holy ſhrine,
" Inſults our offerings, and derides our vows,—
" Oh! ſtrike the diadem from his impious brows,
" Tear from his murderous hand the bloody rod,
" And teach the trembling nations," " *Thou art* GOD!"—
—*Sylphs!* in what dread array with pennons broad 290
Onward ye floated o'er ethereal road,
Call'd each dank ſteam the reeking marſh exhales,
Contagious vapours, and volcanic gales,

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*Volcanic gales.* l. 294. The peſtilential winds of the eaſt are deſcribed by various authors under various denominations; as harmattan, ſamiel, ſamium, ſyrocca, kamſin, ſeravanſum. M. de Beauchamp deſcribes a remarkable ſouth wind in the deſerts about Bagdad, called ſeravanſum, or poiſon-wind; it burns the face, impedes reſpiration, ſtrips the trees of their leaves, and is ſaid to paſs on in a ſtraight line, and often kills people in ſix hours. P. Cotte ſur la Meteorol. Analytical Review for February, 1790. M. Volney ſays, the hot wind or ramſin ſeems to blow at the ſeaſon when the ſands of the deſerts are the hotteſt; the air is then filled with an extremely ſubtle duſt. Vol. I. p. 61. Theſe winds blow in all directions from the deſerts; in Egypt the moſt violent proceed from the S. S. W. at Mecca from the E. at Surat from the N. at Baſſora from the N. W. at Bagdad from the W. and in Syria from the S. E.

On the ſouth of Syria, he adds, where the Jordan flows is a country of volcanos; and it is obſerved that the earthquakes in Syria happen after their rainy ſeaſon, which is alſo conformable to a ſimilar obſervation made by Dr. Shaw in Barbary. Travels in Egypt, Vol. I. p. 303.

Gave the ſoft South with poiſonous breath to blow,
And rolled the dreadful whirlwind on the foe!—
Hark! o'er the camp the venom'd tempeſt ſings,
Man falls on Man, on buckler buckler rings;
Groan anſwers groan, to anguiſh anguiſh yields,
And Death's loud accents ſhake the tented fields;
—High rears the Fiend his grinning jaws, and wide
Spans the pale nations with coloſſal ſtride,
Waves his broad falſhion with uplifted hand,
And his vaſt ſhadow darkens all the land.

IX. 1. "Ethereal cohorts! Eſſences of Air!
Make the green children of the Spring your care!
Oh, *Sylphs!* diſcloſe in this inquiring age
One *Golden Secret* to ſome favour'd ſage;
Grant the charm'd taliſman, the chain, that binds,
Or guides the changeful pinions of the winds!

Theſe winds ſeem all to be of volcanic origin, as before mentioned, with this difference, that the Simoom is attended with a ſtream of electric matter; they ſeem to be in conſequence of earthquakes cauſed by the monſoon floods, which fall on volcanic fires in Syria, at the ſame time that they inundate the Nile.

*One golden ſecret.* l. 308. The ſuddenneſs of the change of the wind from N. E. to S. W. ſeems to ſhew that it depends on ſome minute chemical cauſe; which if it was diſcovered might probably, like other chemical cauſes, be governed by human agency; ſuch as blowing up rocks by gunpowder, or extracting the lightening from the clouds. If this could be accompliſhed, it would be the moſt happy diſcovery that ever has happened to theſe northern latitudes, ſince in this country the N. E. winds bring froſt, and the S. W. ones are attended with warmth and moiſture; if the inferior currents of air could be kept perpetually from the S. W. ſupplied by new productions of air at the line, or by ſuperior currents flowing in a contrary direction, the vegetation of this country would be doubled; as in the moiſt vallies of Africa, which know no froſt; the number of its inhabitants would be increaſed, and their lives prolonged; as great abundance of the aged and infirm of mankind, as well as many birds and animals, are deſtroyed by ſevere continued froſts in this climate.

—No more ſhall hoary Boreas, iſſuing forth
With Eurus, lead the tempeſts of the North;
Rime the pale Dawn, or veil'd in flaky ſhowers
Chill the ſweet boſoms of the ſmiling Hours.
By whiſpering Auſter waked ſhall Zephyr riſe,
Meet with ſoft kiſs, and mingle in the ſkies,
Fan the gay floret, bend the yellow ear,
And rock the uncurtain'd cradle of the year;
Autumn and Spring in lively union blend,
And from the ſkies the Golden Age deſcend.

2. "Caſtled on ice, beneath the circling Bear,
A vaſt CAMELION ſpits and ſwallows air;
O'er twelve degrees his ribs gigantic bend,
And many a league his leathern jaws extend;
Half-fiſh, beneath, his ſcaly volutes ſpread,
And vegetable plumage creſts his head;
Huge fields of air his wrinkled ſkin receives,
From panting gills, wide lungs, and waving leaves!
Then with dread throes ſubſides his bloated form,
His ſhriek the thunder, and his ſigh the ſtorm.
Oft high in heaven the hiſſing Demon wins
His towering courſe, upborne on winnowing fins:
Steers with expanded eye and gaping mouth,
His maſs enormous to the affrighted South;
Spreads o'er the ſhuddering Line his ſhadowy limbs,
And Froſt and Famine follow as he ſwims.—
*Sylphs!* round his cloud-built couch your bands array,
And mould the Monſter to your gentle ſway;
Charm with ſoft tones, with tender touches check,
Bend to your golden yoke his willing neck,

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*A vaſt Camelion.* l. 322. See addititional notes, No. XXXIII. on the deſtruction and reproduction of the atmoſphere.

With ſilver curb his yielding teeth reſtrain,
And give to KIRWAN's hand the ſilken rein.
—Pleaſed ſhall the Sage, the dragon-wings between,
Bend o'er diſcordant climes his eye ſerene,
With Lapland breezes cool Arabian vales,
And call to Hindoſtan antarctic gales,
Adorn with wreathed ears Kampſchatca's brows,
And ſcatter roſes on Zealandic ſnows,
Earth's wondering Zones the genial ſeaſons ſhare,
And nations hail him "*Monarch of the Air.*"

X. 1. "*Sylphs!* as you hover on ethereal wing,
Brood the green children of parturient Spring!—
Where in their burſting cells my Embryons reſt,
I charge you guard the vegetable neſt;
Count with nice eye the myriad *Seeds*, that ſwell
Each vaulted womb of huſk, or pod, or ſhell;

*To Kirwan's hand.* l. 342. Mr. Kirwan has publiſhed a valuable treatiſe on the temperature of climates, as a ſtep towards inveſtigating the theory of the winds; and has ſince written ſome ingenious papers on this ſubject in the Tranſactions of the Royal Iriſh Society.

*The myriad ſeeds.* l. 355. Nature would ſeem to have been wonderfully prodigal in the ſeeds of vegetables, and the ſpawn of fiſh; almoſt any one plant, if all its ſeeds ſhould grow to maturity, would in a few years alone people the terreſtrial globe. Mr. Ray aſſerts that 1012 ſeeds of tobacco weighed only one grain, and that from one tobacco plant the ſeeds thus calculated amounted to 360,000! The ſeeds of the ferns are by him ſuppoſed to exceed a million on a leaf. As the works of nature are governed by general laws this exuberant reproduction prevents the accidental extinction of the ſpecies, at the ſame time that they ſerve for food for the higher orders of animation.

Every ſeed poſſeſſes a reſervoir of nutriment deſigned for the growth of the future plant, this conſiſts of ſtarch, mucilage, or oil, within the coat of the ſeed, or of ſugar and ſubacid pulp in the fruits, which belongs to it.

For the preſervation of the immature ſeed nature has uſed many ingenious methods; ſome are wrapped in down, as the ſeeds of the roſe, bean, and cotton plant; others are ſuſpended in a large air-veſſel, as thoſe of the bladder-ſena, ſtaphylæa, and pea.

Feed with ſweet juices, clothe with downy hair,
Or hang, inſhrined, their little orbs in air.

"So, late deſcry'd by HERSCHEL's piercing ſight,
Hang the bright ſquadrons of the twinkling Night;
Ten thouſand marſhall'd ſtars, a ſilver zone,
Effuſe their blended luſtres round her throne;
Suns call to ſuns, in lucid clouds conſpire,
And light exterior ſkies with golden fire;
Reſiſtleſs rolls the illimitable ſphere,
And one great circle forms the unmeaſured year.
—Roll on, *ye Stars!* exult in youthful prime,
Mark with bright curves the printleſs ſteps of Time;
Near and more near your beamy cars approach,
And leſſening orbs on leſſening orbs encroach;—
Flowers of the ſky! ye too to age muſt yield,
Frail as your ſilken ſiſters of the field!
Star after ſtar from Heaven's high arch ſhall ruſh,
Suns ſink on ſuns, and ſyſtems ſyſtems cruſh,
Headlong, extinct, to one dark centre fall,
And Death and Night and Chaos mingle all;
—Till o'er the wreck, emerging from the ſtorm,
Immortal *Nature* lifts her changeful form,

*And light exterior.* l. 364. I ſuſpect this line is from Dwight's Conqueſt of Canaan, a poem written by a very young man, and which contains much fine verſification.

*Near and more near.* l. 369. From the vacant ſpaces in ſome parts of the heavens, and the correſpondent cluſters of ſtars in their vicinity, Mr. Herſchel concludes that the nebulæ or conſtellations of fixed ſtars are approaching each other, and muſt finally coaleſce in one maſs. Phil. Tranſ. Vol. LXXV.

*Till o'er the wreck.* l. 377. The ſtory of the phenix riſing from its own aſhes with a twinkling ſtar upon its head, ſeems to have been an antient hieroglyphic emblem of the deſtruction and reſuſcitation of all things.

Mounts from her funeral pyre on wings of flame,
And ſoars and ſhines, another and the ſame. 380

2. " Lo! on each *Seed* within its ſlender rind
Life's golden threads in endleſs circles wind;
Maze within maze the lucid webs are roll'd,
And, as they burſt, the living flame unfold.
The pulpy acorn, ere it ſwells, contains 385
The Oak's vaſt branches in its milky veins;
Each ravel'd bud, fine film, and fibre-line
Traced with nice pencil on the ſmall deſign.
The young Narciſſus, in it's bulb compreſs'd,
Cradles a ſecond neſtling on its breaſt; 390

There is a figure of the great Platonic year with a phenix on his hand on the reverſe of a medal of Adrian. Spence's Polym. p. 189.

*Maze within maze.* l. 383. The elegant appearance on diſſection of the young tulip in the bulb was firſt obſerved by Mariotte and is mentioned in the note on tulipa in Vol. II. and was afterwards noticed by Du Hamel. Acad. Scien. Lewenhook aſſures us that in the bud of a currant tree he could not only diſcover the ligneous part but even the berries themſelves, appearing like ſmall grapes. Chamb. Dict. art. Bud. Mr. Baker ſays he diſſected a ſeed of trembling graſs in which a perfect plant appeared with its root, ſending forth two branches, from each of which ſeveral leaves or blades of graſs proceeded. Microſc. Vol. I. p. 252. Mr. Bonnet ſaw four generations of ſucceſſive plants in the bulb of a hyacinth. Bonnet Corps Organ. Vol. I. p. 103. Haller's Phyſiol. Vol. I. p. 91. In the terminal bud of a horſe-cheſnut the new flower may be ſeen by the naked eye covered with a mucilaginous down, and the ſame in the bulb of a narciſſus, as I this morning obſerved in ſeveral of them ſent me by Miſs for that purpoſe. Sept. 16.

Mr. Ferber ſpeaks of the pleaſure he received in obſerving in the buds of Hepatica and pedicularis hirſuta yet lying hid in the earth, and in the gems of the ſhrub daphne mezereon, and at the baſe of oſmunda lunaria a perfect plant of the future year, diſcernable in all its parts a year before it comes forth, and in the ſeeds of nymphea nelumbo the leaves of the plant were ſeen ſo diſtinctly that the author found out by them what plant the ſeeds belonged to. The ſame of the ſeeds of the tulip tree or liriodendum tulipiferum. Amæn. Aced. Vol. VI.

In whoſe fine arms a younger embryon lies,
Folds its thin leaves, and ſhuts its floret-eyes;
Grain within grain ſucceſſive harveſts dwell,
And boundleſs foreſts ſlumber in a ſhell.
—So yon grey precipice, and ivy'd towers,
Long winding meads, and intermingled bowers,
Green files of poplars, o'er the lake that bow,
And glimmering wheel, which rolls and foams below,
In one bright point with nice diſtinction lie
Plan'd on the moving tablet of the eye.
—So, fold on fold, Earth's wavy plains extend,
And, ſphere in ſphere, its hidden ſtrata bend;—
Incumbent Spring her beamy plumes expands
O'er reſtleſs oceans, and impatient lands,
With genial luſtres warms the mighty ball,
And the GREAT SEED evolves, diſcloſing ALL;
LIFE *buds* or *breathes* from Indus to the Poles,
And the vaſt ſurface kindles, as it rolls!

3. "Come, *ye ſoft Sylphs!* who ſport on Latian land,
Come, ſweet-lip'd Zephyr, and Favonius bland;
Teach the fine *Seed*, inſtinct with life, to ſhoot
On Earth's cold boſom its deſcending root;

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*And the great ſeed.* l. 406. Alluding to the *πρωτον ωον*, or firſt great egg of the antient philoſophy, it had a ſerpent wrapped round it emblematical of divine wiſdom, an image of it was afterwards preſerved and worſhipped in the temple of Dioſcuri, and ſuppoſed to repreſent the egg of Leda. See a print of it in Bryant's Mythology. It was ſaid to have been broken by the horns of the celeſtial bull, that is, it was hatched by the warmth of the ſpring. See note on Canto I. l. 413.

*And the vaſt ſurface.* l. 408. L'Organization, le ſentiment, le movement ſpontané, la vie, n'exiſtent qu'a la ſurface de la terre, et dans le lieux expoſes à la lumieré. Traité de Chymie par M. Lavoiſier, Tom. I. p. 202.

*Teach the fine ſeed.* l. 411. The ſeeds in their natural ſtate fall on the ſurface of the earth, and having abſorbed ſome moiſture the root ſhoots

With Pith elaſtic ſtretch its riſing ſtem,
Part the twin Lobes, expand the throbbing Gem;
Claſp in your airy arms the aſpiring Plume,
Fan with your balmy breath its kindling bloom,
Each widening ſcale and burſting film unfold,
Swell the green cup, and tint the flower with gold;
While in bright veins the ſilvery Sap aſcends,
And refluent blood in milky eddies bends;
While, ſpread in air, the leaves reſpiring play,
Or drink the golden quinteſſence of day.

itſelf downwards into the earth and the plume riſes in air. Thus each endeavouring to ſeek its proper pabulum directed by a vegetable irritability ſimilar to that of the lacteal ſyſtem and to the lungs in animals.

The pith ſeems to puſh up or elongate the bud by its elaſticity, like the pith in the callow quills of birds. This medulla Linneus believes to conſiſt of a bundle of fibres, which diverging breaks through the bark yet gelatinous producing the buds.

The lobes are reſervoirs of prepared nutriment for the young ſeed, which is abſorbed by its placental veſſels, and converted into ſugar, till it has penetrated with its roots far enough into the earth to extract ſufficient moiſture, and has acquired leaves to convert it into nouriſhment. In ſome plants theſe lobes riſe from the earth and ſupply the place of leaves, as in kidney-beans, cucumbers, and hence ſeem to ſerve both as a placenta to the fœtus, and lungs to the young plant. During the proceſs of germination the ſtarch of the ſeed is converted into ſugar, as is ſeen in the proceſs of malting barley for the purpoſe of brewing. And is on this account very ſimilar to the digeſtion of food in the ſtomachs of animals, which converts all their aliment into a chyle, which conſiſts of mucilage, oil, and ſugar; the placentation of buds will be ſpoken of hereafter.

*The ſilvery ſap.* l. 419. See additional notes, No. XXXVI.

*Or drink the golden.* l. 422. Linneus having obſerved the great influence of light on vegetation, imagined that the leaves of plants inhaled electric matter from the light with their upper ſurface. (Syſtem of Vegetables tranſlated, p. 8.)

The effect of light on plants occaſions the actions of the vegetable muſcles of their leaf-ſtalks, which turn the upper ſide of the leaf to the light, and which open their calyxes and chorols, according to the experiments of Abbe Teſſier, who expoſed variety of plants in a cavern to different quantities of light. Hiſt. de L'Academie Royal. Ann. 1783.

— So from his ſhell on Delta's ſhower-leſs iſle
Burſts into life the Monſter of the Nile;
Firſt in tranſlucent lymph with cobweb-threads
The Brain's fine floating tiſſue ſwells, and ſpreads;
Nerve after nerve the gliſtening ſpine deſcends,
The red Heart dances, the Aorta bends;
Through each new gland the purple current glides,
New veins meandering drink the refluent tides;
Edge over edge expands the hardening ſcale,
And ſheaths his ſlimy ſkin in ſilver mail.
—Erewhile, emerging from the brooding ſand,
With Tyger-paw He prints the brineleſs ſtrand,
High on the flood with ſpeckled boſom ſwims,
Helm'd with broad tail, and oar'd with giant limbs;
Rolls his fierce eye-balls, claſps his iron claws,
And champs with gnaſhing teeth his maſſy jaws;
Old Nilus ſighs along his cane-crown'd ſhores,
And ſwarthy Memphis trembles and adores.

XI. "Come, *ye ſoft Sylphs!* who fan the Paphian groves,
And bear on ſportive wings the callow Loves;
Call with ſweet whiſper, in each gale that blows,
The ſlumbering Snow-drop from her long repoſe;
Charm the pale Primroſe from her clay-cold bed,
Unveil the baſhful Violet's tremulous head;
While from her bud the playful Tulip breaks,
And young Carnations peep with bluſhing cheeks;
Bid the cloſed *Petals* from nocturnal cold
The virgin *Style* in ſilken curtains fold,
Shake into viewleſs air the morning dews,
And wave in light their irideſcent hues;

---

The ſleep or vigilance of plants ſeems owing to the preſence or abſence of this ſtimulus. See note on Nimoſa, Vol. II.

While from on high the burſting *Anthers* truſt
To the mild breezes their prolific duſt;
Or bend in rapture o'er the central Fair,
Love out their hour, and leave their lives in air.
So in his ſilken ſepulchre the Worm,
Warm'd with new life, unfolds his larva-form;
Erewhile aloft in wanton circles moves,
And woos on Hymen-wings his velvet loves.

XII. 1. "If prouder branches with exuberance rude
Point their green gems, their barren ſhoots protrude;
Wound them, ye *Sylphs!* with little knives, or bind
A wiry ringlet round the ſwelling rind;

---

*Love out their hour.* l. 456. The vegetable paſſion of love is agreeably ſeen in the flower of the parnaſſia, in which the males alternately approach and recede from the female, and in the flower of nigella, or devil in the buſh, in which the tall females bend down to their dwarf huſbands. But I was this morning ſurpriſed to obſerve, amongſt Sir Brooke Boothby's valuable collection of plants at Aſhbourn, the manifeſt adultery of ſeveral females of the plant Collinſonia, who had bent themſelves into contact with the males of other flowers of the ſame plant in their vicinity, neglectful of their own. Sept. 16. See additional notes, No. XXXVIII.

*Wound them, ye Sylphs!* l. 463. Mr. Whitmill adviſed to bind ſome of the moſt vigorous ſhoots with ſtrong wire, and even ſome of the large roots; and Mr. Warner cuts, what he calls a wild worm about the body of the tree, or ſcores the bark quite to the wood like a ſcrew with a ſharp knife. Bradley on Gardening, Vol. II. p. 155. Mr. Fitzgerald produced flowers and fruit on wall trees by cutting off a part of the bark. Phil. Tranſ. Ann. 1761. M. Buffon produced the ſame effect by a ſtraight bandage put round a branch, Act. Paris, Ann. 1738, and concludes that an ingrafted branch bears better from its veſſels being compreſſed by the callous.

A compleat cylinder of the bark about an inch in height was cut off from the branch of a pear tree againſt a wall in Mr. Howard's garden at Lichfield about five years ago, the circumciſed part is now not above half the diameter of the branch above and below it, yet this branch has been full of fruit every year ſince, when the other branches of the tree bore only ſparingly. I late obſerved that the leaves of this wounded branch were ſmaller and paler, and the fruit leſs in ſize, and ripened ſooner than

Biſect with chiſſel fine the root below,
Or bend to earth the inhoſpitable bough.
So ſhall each germ with new prolific power
Delay the leaf-bud, and expand the flower;
Cloſed in the *Style* the tender pith ſhall end,
The lengthening Wood in circling *Stamens* bend;
The ſmoother Rind its ſoft embroidery ſpread
In vaulted *Petals* o'er their fertile bed;
While the rough Bark, in circling mazes roll'd,
Forms the green *Cup* with many a wrinkled fold;
And each ſmall bud-ſcale ſpreads its ſoliage hard,
Firm round the callow germ, a *Floral Guard*.

2. "Where cruder juices ſwell the leaſy vein,
Stint the young germ, the tender bloſſom ſtain;

---

on the other parts of the tree. Another branch has the bark taken off not quite all round with much the ſame effect.

The theory of this curious vegetable fact has been eſteemed difficult, but receives great light from the foregoing account of the individuality of buds. A flower-bud dies, when it has perfected its ſeed, like an annual plant, and hence requires no place on the bark for new roots to paſs downwards; but on the contrary leaf-buds, as they advance into ſhoots, form new buds in the axilla of every leaf, which new buds require new roots to paſs down the bark, and thus thicken as well as elongate the branch, now if a wire or ſtring be tied round the bark, many of theſe new roots cannot deſcend, and thence more of the buds will be converted into flower-buds.

*Or bend to earth.* l. 466. Mr. Hitt in his treatiſe on fruit trees obſerves that if a vigorous branch of a wall tree be bent to the horizon, or beneath it, it loſes its vigour and becomes a bearing branch. The theory of this I ſuppoſe to depend on the difficulty with which the leaf-ſhoots can protrude the roots neceſſary for their new progeny of buds upwards along the bended branch to the earth contrary to their natural habits or powers, whence more flower-ſhoots are produced which do not require new roots to paſs along the bark of the bended branch, but which let their offspring, the ſeeds, fall upon the earth and ſeek roots for themſelves.

On each lop'd ſhoot a foſter ſcion bind,
Pith preſs'd to pith, and rind applied to rind, 480
So ſhall the trunk with loftier creſt aſcend,
And wide in air its happier arms extend;
Nurſe the new buds, admire the leaves unknown,
And bluſhing bend with fruitage not its own.

"Thus when in holy triumph Aaron trod, 485
And offer'd on the ſhrine his myſtic rod;
Firſt a new bark its ſilken tiſſue weaves,
New buds emerging widen into leaves;
Fair fruits protrude, enaſcent flowers expand,
And bluſh and tremble round the living wand. 490

XIII. 1. "*Sylphs!* on each Oak-bud wound the wormy galls,
With pigmy ſpears, or cruſh the venom'd balls;
Fright the green Locuſt from his ſoamy bed,
Unweave the Caterpillar's gluey thread;

---

*Nurſe the new buds*, l. 483. Mr. Fairchild budded a paſſion-tree, whoſe leaves were ſpotted with yellow, into one which bears long fruit. The buds did not take, nevertheleſs in a fortnight yellow ſpots began to ſhew themſelves about three feet above the inoculation, and in a ſhort time afterwards yellow ſpots appeared on a ſhoot which came out of the ground from another part of the plant. Bradley, Vol. II. p. 129. Theſe facts are the more curious ſince from experiments of ingrafting red currants on black (Ib. Vol. II.) the fruit does not acquire any change of flavour, and by many other experiments neither colour nor any other change is produced in the fruit ingrafted on other ſtocks.

There is an apple deſcribed in Bradley's work which is ſaid to have one ſide of it a ſweet fruit which boils ſoft, and the other ſide a ſour fruit which boils hard, which Mr. Bradley ſo long ago as the year 1721 ingeniouſly aſcribes to the farina of one of theſe apples impregnating the other, which would ſeem the more probable if we conſider that each diviſion of an apple is a ſeparate womb, and may therefore have a ſeparate impregnation like puppies of different kinds in one litter. The ſame is ſaid to have occurred in oranges and lemons, and grapes of different colours.

Chaſe the fierce Earwig, ſcare the bloated Toad,
Arreſt the ſnail upon his ſlimy road ;
Arm with ſharp thorns the Sweet-brier's tender wood,
And daſh the Cynips from her damaſk bud ;
Steep in ambroſial dews the Woodbine's bells,
And drive the Night-moth from her honey'd cells.
So where the Humming-bird in Chili's bowers
On murmuring pinions robs the pendent flowers ;
Seeks, where fine pores their dulcet balm diſtill,
And ſucks the treaſure with proboſcis-bill ;
Fair CYPREPEDIA with ſucceſsful guile
Knits her ſmooth brow, extinguiſhes her ſmile ;
A Spider's bloated paunch and jointed arms
Hide her fine form, and maſk her bluſhing charms ;

---

*Fair Cyprepedia.* l. 505. The cyprepedium from South America is ſuppoſed to be of larger ſize and brighter colours than that from North America from which this print is taken ; it has a large globular nectary about the ſize of a pidgeon's egg of a fleſhy colour, and an inciſion or depreſſion on its upper part, much reſembling the body of the large American ſpider ; this globular nectary is attached to divergent ſlender petals not unlike the legs of the ſame animal. This ſpider is called by Linneus Arenea avicularia, with a convex orbicular thorax, the center tranſverſely excavated, he adds that it catches ſmall birds as well as inſects, and has the venomous bite of a ſerpent. Syſtem Nature, Tom. I. p. 1034. M. Lonvilliers de Poincy, (Hiſtoire Nat. des Antilles, Cap. xiv. art. III.) calls it Phalange, and deſcribes the body to be the ſize of a pidgeon's egg, with a hollow on its back like a navel, and mentions its catching the humming-bird in its ſtrong nets.

The ſimilitude of this flower to this great ſpider ſeems to be a vegetable contrivance to prevent the humming-bird from plundering its honey. About Matlock in Derbyſhire the fly-ophris is produced, the nectary of which ſo much reſembles the ſmall wall-bee, perhaps the apis ichneumonea, that it may be eaſily miſtaken for it at a ſmall diſtance. It is probable that by this means it may often eſcape being plundered. See note on lonicera in the next poem.

A bird of our own country called a willow-wren (Motacilla runs up the ſtem of the crown-imperial (Frittillaria coronalis) and ſips the

In ambuſh ſly the mimic warrior lies,
And on quick wing the panting plunderer flies. 510

2. "Shield the young Harveſt from devouring blight,
The Smut's dark poiſon, and the Mildew white;
Deep-rooted Mould, and Ergot's horn uncouth,
And break the Canker's deſolating tooth.
Firſt in one point the feſtering wound confin'd 515
Mines unperceived beneath the ſhrivel'd rind;
Then climbs the branches with increaſing ſtrength,
Spreads as they ſpread, and lengthens with their length;

---

pendulous drops within its petals. This ſpecies of Motacilla is called by Ray Regulus non criſtatus. White's Hiſt. of Selborne.

*Shield the young harveſt.* l. 511. Linneus enumerates but four diſeaſes of plants; Eryſyche, the white mucor or mould, with ſeſſile tawny heads, with which the leaves are ſprinkled, as is frequent on the hop, humulus, maple, acer, &c. Rubigo, the ferrugineous powder ſprinkled under the leaves frequent in lady's mantle, alchemilla, &c.

Calvus, when the ſeeds grow out into larger horns black without, as in rye. This is called Ergot by the French writers.

Uſtulago, when the fruit inſtead of ſeed produces a black powder, as in barley, oats, &c. To which perhaps the honey-dew ought to have been added, and the canker, in the former of which the nouriſhing fluid of the plant ſeems to be exſuded by a retrograde motion of the cutaneous lymphatics, as in the ſweating ſickneſs of the laſt century. The latter is a phagedenic ulcer of the bark, very deſtructive to young apple-trees, and which in cherry-trees is attended with a depoſition of gum arabic, which often terminates in the death of the tree.

*Ergot's horn.* l. 513. There is a diſeaſe frequently affects the rye in France, and ſometimes in England in moiſt ſeaſons, which is called Ergot, or horn ſeed; the grain becomes conſiderably elongated and is either ſtraight or crooked, containing black meal along with the white, and appears to be pierced by inſects, which were probably the cauſe of the diſeaſe. Mr. Duhamel aſcribes it to this cauſe, and compares it to galls on oak-leaves. By the uſe of this bad grain amongſt the poor, diſeaſes have been produced attended with great debility and mortification of the extremities both in France and England. Dict. Raiſon. art. Siegle. Philoſop. Tranſact.

—Thus the ſlight wound ingraved on glaſs unneal'd
Runs in white lines along the lucid field;
Crack follows crack, to laws elaſtic juſt,
And the frail fabric ſhivers into duſt.

XIV. 1. "*Sylphs!* if with morn deſtructive Eurus ſprings,
O, claſp the Harebel with your velvet wings;
Screen with thick leaves the Jaſmine as it blows,
And ſhake the white rime from the ſhuddering Roſe;
Whilſt Amaryllis turns with graceful eaſe
Her bluſhing beauties, and eludes the breeze.—
*Sylphs!* if at noon the Fritillary droops,
With drops nectareous hang her nodding cups;
Thin clouds of Goſſamer in air diſplay,
And hide the vale's chaſte Lily from the ray;

---

*On glaſs unneal'd.* l. 519. The glaſs-makers occaſionally make what they call *proofs*, which are cooled haſtily, whereas the other glaſs veſſels are removed from warmer ovens to cooler ones, and ſuffered to cool by ſlow degrees, which is called annealing, or nealing them. If an unnealed glaſs be ſcratched by even a grain of ſand falling into it, it will ſeem to conſider of it for ſome time, or even a day, and will then crack into a thouſand pieces.

The ſame happens to a ſmooth ſurfaced lead-ore in Derbyſhire, the workmen having cleared a large face of it ſcratch it with picks, and in a few hours many tons of it crack to pieces and fall, with a kind of exploſion. Whitehurſt's Theory of Earth.

Glaſs dropped into cold water, called Prince Rupert's drops, explode when a ſmall part of their tails are broken off, more ſuddenly indeed, but probably from the ſame cauſe. Are the internal particles of theſe elaſtic bodies kept ſo far from each other by the external cruſt that they are nearly in a ſtate of repulſion, into which ſtate they are thrown by their vibrations from any violence applied? Or, like elaſtic balls in certain proportions ſuſpended in contact with each other, can motion once began be increaſed by their elaſticity, till the whole explodes? And can this power be applied to any mechanical purpoſes?

Whilſt Erythrina o'er her tender flower
Bends all her leaves, and braves the ſultry hour;—
Shield, when cold Heſper ſheds his dewy light, 535
Mimoſa's ſoft ſenſations from the night;
Fold her thin foliage, cloſe her timid flowers,
And with ambroſial ſlumbers guard her bowers;
O'er each warm wall while Cerea flings her arms,
And waſtes on night's dull eye a blaze of charms. 540

2. Round her tall Elm with dewy fingers twine
The gadding tendrils of the adventurous Vine;
From arm to arm in gay feſtoons ſuſpend
Her fragrant flowers, her graceful foliage bend;
Swell with ſweet juice her vermil orbs, and feed 545
Shrined in tranſparent pulp her pearly ſeed;
Hang round the Orange all her ſilver bells,
And guard her fragrance with Heſperian ſpells;
Bud after bud her poliſh'd leaves unfold,
And load her branches with ſucceſſive gold. 550
So the learn'd Alchemiſt exulting ſees
Riſe in his bright matraſs **Diana**'s trees;

---

*With ambroſial ſlumbers.* l. 538. Many vegetables during the night do not ſeem to reſpire, but to ſleep like the dormant animals and inſects in winter. This appears from the mimoſa and many other plants cloſing the upper ſides of their leaves together in their ſleep, and thus precluding that ſide of them from both light and air. And from many flowers cloſing up the poliſhed or interior ſide of their petals, which we have alſo endeavoured to ſhew to be a reſpiratory organ.

The irritability of plants is abundantly evinced by the abſorption and pulmonary circulation of their juices; their ſenſibility is ſhewn by the approaches of the males to the females, and of the females to the males in numerous inſtances; and, as the eſſential circumſtance of ſleep conſiſts in the temporary abolition of voluntary power alone, the ſleep of plants evinces that they poſſeſs voluntary power; which alſo indiſputably appears in many of them by cloſing their petals or their leaves during cold, or rain, or darkneſs, or from mechanic violence.

Drop after drop, with juſt delay he pours
The red-fumed acid on Potoſi's ores;
With ſudden flaſh the fierce bullitions riſe,
And wide in air the gas phlogiſtic flies;
Slow ſhoot, at length, in many a brilliant maſs
Metallic roots acroſs the netted glaſs;
Branch after branch extend their ſilver ſtems,
Bud into gold, and bloſſoms into gems.

So ſits enthron'd in vegetable pride
Imperial KEW by Thames's glittering ſide;
Obedient ſails from realms unfurrow'd bring
For her the unnam'd progeny of ſpring;
Attendant Nymphs her dulcet mandates hear,
And nurſe in foſtering arms the tender year,
Plant the young bulb, inhume the living ſeed,
Prop the weak ſtem, the erring tendril lead;
Or fan in glaſs-built fanes the ſtranger flowers
With milder gales, and ſteep with warmer ſhowers.
Delighted Thames through tropic umbrage glides,
And flowers antarctic, bending o'er his tides;
Drinks the new tints, the ſweets unknown inhales,
And calls the ſons of ſcience to his vales.
In one bright point admiring Nature eyes
The fruits and foliage of diſcordant ſkies,
Twines the gay floret with the fragrant bough,
And bends the wreath round GEORGE's royal brow.
—Sometimes retiring, from the public weal
One tranquil hour the *Royal Partners* ſteal;
Through glades exotic paſs with ſtep ſublime,
Or mark the growths of Britain's happier clime;
With beauty bloſſom'd, and with virtue blaz'd,
Mark the fair Scions, that themſelves have rais'd;

Sweet blooms the Roſe, the towering Oak expands, 585
The Grace and Guard of Britain's golden lands.

XV. *Sylphs!* who, round earth on purple pinions borne,
Attend the radiant chariot of the morn;
Lead the gay hours along the ethereal hight,
And on each dun meridian ſhower the light; 590
*Sylphs!* who from realms of equatorial day
To climes, that ſhudder in the polar ray,
From zone to zone purſue on ſhifting wing,
The bright perennial journey of the ſpring; 595
Bring my rich Balms from Mecca's hallow'd glades,
Sweet flowers, that glitter in Arabia's ſhades;
Fruits, whoſe fair forms in bright ſucceſſion glow
Gilding the Banks of Arno, or of Po;
Each leaf, whoſe fragrant ſteam with ruby lip
Gay China's nymphs from pictur'd vaſes ſip; 600
Each ſpicy rind, which ſultry India boaſts,
Scenting the night-air round her breezy coaſts;
Roots whoſe bold ſtems in bleak Siberia blow,
And gem with many a tint the eternal ſnow;
Barks, whoſe broad umbrage high in ether waves 605
O'er Ande's ſteeps, and hides his golden caves;
—And, where yon oak extends his duſky ſhoots
Wide o'er the rill, that bubbles from his roots;
Beneath whoſe arms, protected from the ſtorm
A turf-built altar rears it's ruſtic form; 610
SYLPHS! with religious hands freſh garlands twine,
And deck with laviſh pomp HYGEIA's ſhrine.

"Call with loud voice the Siſterhood, that dwell
On floating cloud, wide wave, or bubbling well;
Stamp with charm'd foot, convoke the alarmed Gnomes
From golden beds, and adamantine domes; 615

Each from her ſphere with beckoning arm invite,
Curl'd with red flame, the Veſtal Forms of light.
Cloſe all your ſpotted wings, in lucid ranks
Preſs with your bending knees the crowded banks,
Croſs your meek arms, incline your wreathed brows,
And win the Goddeſs with unwearied vows.

"Oh, wave, HYGEIA! o'er BRITANNIA's throne
Thy ſerpent-wand, and mark it for thy own;
Lead round her breezy coaſts thy guardian trains,
Her nodding foreſts, and her waving plains;
Shed o'er her peopled realms thy beamy ſmile,
And with thy airy temple crown her iſle!"

The *Goddeſs* ceaſed,—and calling from afar
The wandering Zephyrs, joins them to her car;
Mounts with light bound, and graceful, as ſhe bends,
Whirls the long laſh, the flexile rein extends;
On whiſpering wheels the ſilver axle ſlides,
Climbs into air, and cleaves the cryſtal tides;
Burſt from its pearly chains, her amber hair
Streams o'er her ivory ſhoulders, buoy'd in air;
Swells her white veil, with ruby claſp confined
Round her fair brow, and undulates behind;
The leſſening courſers riſe in ſpiral rings,
Pierce the ſlow-ſailing clouds, and ſtretch their ſhadowy
wings.

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# ADDITIONAL NOTES.

## NOTE I.—METEORS.

*Etherial Forms! you chaſe the ſhooting ſtars,*
*Or yoke the vollied lightnings to your cars.*
CANTO I. l. 115.

THERE ſeem to be three concentric ſtrata of our incumbent atmoſphere; in which, or between them, are produced four kinds of meteors; lightning, ſhooting ſtars, fire-balls, and northern lights. Firſt, the lower region of air, or that which is denſe enough to reſiſt by the adheſion of its particles the deſcent of condenſed vapour, or clouds, which may extend from one to three or four miles high. In this region the common lightning is produced from the accumulation or defect of electric matter in thoſe floating fields of vapour either in reſpect to each other, or in reſpect to the earth beneath them, or the diſſolved vapour above them, which is conſtantly varying both with the change of the form of the clouds, which thus evolve a greater or leſs ſurface; and alſo with their ever-changing degree of condenſation. As the lightning is thus produced in denſe air, it proceeds but a ſhort courſe on account of the greater reſiſtance which it encounters, is attended with a loud exploſion, and appears with a red light.

2. The ſecond region of the atmoſphere I ſuppoſe to be that which has too little tenacity to ſupport condenſed vapour or clouds; but which yet contains inviſible vapour, or water in aerial ſolution. This aerial ſolution of water differs from that diſſolved in the matter of heat, as it is ſupported by its adheſion to the particles of air, and is not precipitated by cold. In this ſtratum it ſeems probable that the meteors called ſhooting ſtars are produced; and that they conſiſt of electric ſparks, or lightning, paſſing from one region to another of theſe inviſible fields of aero-aqueous ſolution. The height of theſe ſhooting ſtars has not yet been

aſcertained by ſufficient obſervation; Dr. Blagden thinks their ſituation is lower down in the atmoſphere than that of fireballs, which he conjectures from their ſwiſt apparent motion, and aſcribes their ſmallneſs to the more minute diviſion of the electric matter of which they are ſuppoſed to conſiſt, owing to the greater reſiſtance of the denſer medium through which they paſs, than that in which the fire-balls exiſt. Mr. Brydone obſerved that the ſhooting ſtars appeared to him to be as high in the atmoſphere, when he was near the ſummit of mount Etna, as they do when obſerved from the plain. Phil. Tranſ. Vol. LXIII.

As the ſtratum of air, in which ſhooting ſtars are ſuppoſed to exiſt is much rarer than that in which lightning reſides, and yet much denſer than that in which fire-balls are produced, they will be attracted at a greater diſtance than the former, and at a leſs than the latter. From this rarity of the air ſo ſmall a ſound will be produced by their exploſion, as not to reach the lower parts of the atmoſphere; their quantity of light from their greater diſtance being ſmall, is never ſeen through denſe air at all, and thence does not appear red, like lightning or fire-balls. There are no apparent clouds to emit or to attract them, becauſe the conſtituent parts of theſe aero-aqueous regions may poſſeſs an abundance or deficiency of electric matter and yet be in perfect reciprocal ſolution. And laſtly their apparent train of light is probably owing only to a continuance of their impreſſion on the eye; as when a fire-ſtick is whirled in the dark it gives the appearance of a compleat circle of fire: for theſe white trains of ſhooting ſtars quickly vaniſh, and do not ſeem to ſet any thing on fire in their paſſage, as ſeems to happen in the tranſit of fire-balls.

3. The ſecond region or ſtratum of air terminates I ſuppoſe where the twilight ceaſes to be refracted, that is, where the air is 3000 times rarer than at the ſurface of the earth; and where it ſeems probable that the common air ends, and is ſurrounded by an atmoſphere of inflammable gas tenfold rarer than itſelf. In this region I believe fire-balls ſometimes to paſs, at other times the northern lights to exiſt. One of theſe fire-balls or draco volans, was obſerved by Dr. Pringle and many others on Nov. 26, 1758, which was afterwards eſtimated to have been a mile and a half in circumference, to have been about one hundred miles high, and to have moved towards the north with a velocity of near thirty miles in a ſecond of time. This meteor had a real tail many miles long, which threw off ſparks in its courſe, and the whole exploded with a ſound like diſtant thunder. Philoſ. Tranſ. Vol. LI.

Dr. Blagden has related the hiſtory of another large meteor, or fire-ball, which was ſeen the 18th of Auguſt, 1783, with many ingenious obſervations and conjectures. This was eſtimated to be between 60 and 70 miles high, and to travel 1000 miles at the rate of about twenty miles in a ſecond. This fire-ball had likewiſe a real train of light left behind it in its paſſage, which varied in colour; and in ſome part of its courſe gave off ſparks or exploſions where it had been brighteſt; and a duſky red ſtreak remained viſible perhaps a minute. Philoſ. Tranſ. Vol. LXXIV.

Theſe fire-balls differ from lightning, and from ſhooting ſtars in many remarkable circumſtances; as their very great bulk, being a mile and a half in diameter; their travelling 1000 miles nearly horizontally; their throwing off ſparks in their paſſage; and changing colours from bright blue to duſky red; and leaving a train of fire behind them, continuing about a minute. They differ from the northern lights in not being diffuſed, but paſſing from one point of the heavens to another in a defined line; and this in a region above the crepuſcular atmoſphere, where the air is 3000 times rarer than at the ſurface of the earth. There has not yet been even a conjecture which can account for theſe appearances!—One I ſhall therefore hazard; which, if it does not inform, may amuſe the reader.

In the note on l. 123, it was ſhewn that there is probably a ſupernatant ſtratum of inflammable gas or hydrogene, over the common atmoſphere; and whoſe denſity at the ſurface where they meet, muſt be at leaſt ten times leſs than that upon which it ſwims; like chemical ether floating upon water, and perhaps without any real contact. 1. In this region, where the aerial atmoſphere terminates and the inflammable one begins, the quantity of tenacity or reſiſtance muſt be almoſt inconceivable; in which a ball of electricity might paſs 1000 miles with greater eaſe than through a thouſandth part of an inch of glaſs. 2. Such a ball of electricity paſſing between inflammable and common air would ſet fire to them in a line as it paſſed along; which would differ in colour according to the greater proportionate commixture of the two airs; and from the ſame cauſe there might occur greater degrees of inflammation, or branches of fire, in ſome parts of its courſe.

As theſe fire-balls travel in a defined line, it is pretty evident from the known laws of electricity, that they muſt be attracted; and as they are a mile or more in diameter, they muſt be emitted from a large ſurface of electric matter; becauſe large nobs give larger ſparks, leſs diffuſed, and more brightly luminous, than leſs ones or points, and reſiſt more forceably the emiſſion of the electric matter. What is there in nature can attract them at ſo great a diſtance as 1000 miles, and ſo forceably as to detach an electric ſpark of a mile diameter? Can volcanos at the time of their eruptions have this effect, as they are generally attended with lightning? Future obſervations muſt diſcover theſe ſecret operations of nature! As a ſtream of common air is carried along with the paſſage of electric aura from one body to another; it is eaſy to conceive, that the common air and the inflammable air between which the fire-ball is ſuppoſed to paſs, will be partially intermixed by being thus agitated, and ſo far as it becomes intermixed it will take fire, and produce the linear flame and branching ſparks above deſcribed. In this circumſtance of their being attracted, and thence paſſing in a defined line, the fire-balls ſeem to differ from the coruſcations of the aurora borealis, or northern lights, which probably take place in the ſame region of the atmoſphere; where the common air exiſts in extreme tenuity, and is covered by a ſtill rarer ſphere of inflammable gas, ten times lighter than itſelf.

As the electric ſtreams, which conſtitute theſe northern lights, ſeem to be repelled or radiated from an accumulation of that fluid in the north, and not attracted like the fire-balls; this accounts for the diffuſion of their light, as well as the ſilence of their paſſage; while their variety of colours, and the permanency of them, and even the breadth of them in different places, may depend on their ſetting on fire the mixture of inflammable and common air through which they paſs; as ſeems to happen in the tranſit of the fire-balls.

It was obſerved by Dr. Prieſtley that the electric ſhock taken through inflammable air was red, in common air it is blueiſh; to theſe circumſtances perhaps ſome of the colours of the northern lights may bear analogy; though the denſity of the medium through which light is ſeen muſt principally vary its colour, as is well explained by Mr. Morgan. Phil. Tranſ. Vol. LXXV. Hence lightning is red when ſeen through a dark cloud, or near the horizon; becauſe the more refrangible rays cannot permeate ſo denſe a medium. But the ſhooting ſtars conſiſt of white light, as they are generally ſeen on clear nights, and nearly vertical: in other ſituations their light is probably too faint to come to us. But as in ſome remarkable appearances of the northern lights, as in March, 1716, all the priſmatic colours were ſeen quickly to ſucceed each other, theſe appear to have been owing to real combuſtion; as the denſity of the interpoſed medium could not be ſuppoſed to change ſo frequently; and therefore theſe colours muſt have been owing to different degrees of heat according to Mr. Morgan's theory of combuſtion. In

Smith's Optics, p. 69. the priſmatic colours, and optical deceptions of the northern lights are deſcribed by Mr. Cotes.

The Torricellian vacuum, if perfectly free from air, is ſaid by Mr. Morgan and others to be a perfect non-conductor. This circumſtance therefore would preclude the electric ſtreams from riſing above the atmoſphere. But as Mr. Morgan did not try to paſs an electric ſhock through a vacuum, and as air, or ſomething containing air, ſurrounding the tranſit of electricity may be neceſſary to the production of light, the concluſion may perhaps ſtill be dubious. If however the ſtreams of the northern lights were ſuppoſed to riſe above our atmoſphere, they would only be viſible at each extremity of their courſe; where they emerge from, or are again immerged into the atmoſphere; but not in their journey through the vacuum; for the abſence of electric light in a vacuum is ſufficiently proved by the common experiment of ſhaking a barometer in the dark; the electricity, produced by the friction of the mercury in the glaſs at its top, is luminous if the barometer has a little air in it; but there is no light if the vacuum be complete.

The aurora borealis, or northern dawn, is very ingeniouſly accounted for Dr. Franklin on principles of electricity. He premiſes the following electric phenomena: 1. that all new fallen ſnow has much poſitive electricity ſtanding on its ſurface. 2. That about twelve degrees of latitude round the poles are covered with a cruſt of eternal ice, which is impervious to the electric fluid. 3. That the denſe part of the atmoſphere riſes but a few miles high; and that in the rarer parts of it the electric fluid will paſs to almoſt any diſtance.

Hence he ſuppoſes there muſt be a great accumulation of poſitive electric matter on the freſh fallen ſnow in the polar regions; which, not being able to paſs through the cruſt of ice into the earth, muſt riſe into the rare air of the upper parts of our atmoſphere, which will the leaſt reſiſt its paſſage; and paſſing towards the equator deſcend again into the denſer atmoſphere, and thence into the earth in ſilent ſtreams. And that many of the appearances attending theſe lights are optical deceptions, owing to the ſituation of the eye that beholds them; which makes all aſcending parallel lines appear to converge to a point.

The idea, above explained in note on l. 123, of the exiſtence of a ſphere of inflammable gas over the aerial atmoſphere would much favour this theory of Dr. Franklin; becauſe in that caſe the denſe aerial atmoſphere would riſe a much leſs height in the polar regions, diminiſhing almoſt to nothing at the pole itſelf; and thus give an eaſier paſſage to the aſcent of the electric fluid. And from the great difference in the ſpecific gravity of the two airs, and the velocity of the earth's rotation, there muſt be a place between the poles and the equator, where the ſuperior atmoſphere of inflammable gas would terminate; which would account for theſe ſtreams of the aurora borealis not appearing near the equator; add to this that it is probable the electric fluid may be heavier than the magnetic one; and will thence by the rotation of the earth's ſurface aſcend over the magnetic one by its centrifugal force; and may thus be induced to riſe through the thin ſtratum of aerial atmoſphere over the poles. See note on Canto II. l. 193. I ſhall have occaſion again to mention this great accumulation of inflammable air over the poles; and to conjecture that theſe northern lights may be produced by the union of inflammable with common air, without the aſſiſtance of the electric ſpark to throw them into combuſtion.

The antiquity of the appearance of northern lights has been doubted; as none were recorded in our annals ſince the remarkable one on Nov. 14, 1574, till another remarkable one on March 6, 1716, and the three following nights, which were ſeen at the ſame time in Ireland, Ruſſia, and Poland, extending near 30 degrees of longitude and from about the 50th degree of latitude over almoſt all the north of Europe. There is however reaſon to believe them of remote antiquity though inaccurately deſcribed; thus the following curious paſſage from the Book of Maccabees, (B. II. c. v.) is ſuch a deſcription of them, as might probably be given by an ignorant and alarmed people. "Through all the city, for the ſpace of almoſt forty days, there were ſeen horſemen running in the air, in cloth of gold, and armed with lances, like a band of ſoldiers; and troops of horſemen in array encountering and running one againſt another, with ſhaking of ſhields and multitude of pikes, and drawing of ſwords, and caſting of darts, and glittering of golden ornaments and harneſs."

# NOTE II.——PRIMARY COLOURS,

*Cling round the aerial bow with priſms bright,*
*And pleaſed untwiſt the ſevenfold threads of light.*
CANTO I. l. 117.

THE manner in which the rainbow is produced was in ſome meaſure underſtood before Sir Iſaac Newton had diſcovered his theory of colours. The firſt perſon who expreſsly ſhewed the rainbow to be formed by the reflection of the ſunbeams from drops of falling rain was Antonio de Dominis. This was afterwards more fully and diſtinctly explained by Des Cartes. But what cauſed the diverſity of its colours was not then underſtood; it was reſerved for the immortal Newton to diſcover that the rays of light conſiſted of ſeven combined colours of different refrangibility, which could be ſeparated at pleaſure by a wedge of glaſs. Pemberton's View of Newton.

Sir Iſaac Newton diſcovered that the priſmatic ſpectrum was compoſed of ſeven colours in the following proportions, violet 80, indigo 40, blue 60, green 60, yellow 48, orange 27, red 45. If all theſe colours be painted on a circular card in the proportions above mentioned, and the card be rapidly whirled on its center, they produce in the eye the ſenſation of white. And any one of theſe colours may be imitated by painting a card with the two colours which are contiguous to it, in the ſame proportions as in the ſpectrum, and whirling them in the ſame manner.

My ingenious friend, Mr. Galton of Birmingham, aſcertained in this manner by a ſet of experiments the following propoſitions; the truth of which he had preconceived from the above data.

1. Any colour in the priſmatic ſpectrum may be imitated by a mixture of the two colours contiguous to it.

2. If any three ſucceſſive colours in the priſmatic ſpectrum are mixed, they compoſe only the ſecond or middlemoſt colour.

3. If any four ſucceſſive colours in the priſmatic ſpectrum be mixed, a tint ſimilar to a mixture of the ſecond and third colours will be produced, but not preciſely the ſame, becauſe they are not in the ſame proportion.

4. If beginning with any colour in the circular ſpectrum, you take of the ſecond colour a quantity equal to the firſt, ſecond, and third; and add to that the fifth colour, equal in quantity to the fourth, fifth, and ſixth, and with theſe combine the ſeventh colour in the proportion it

exiſts in the ſpectrum, white will be produced. Becauſe the firſt, ſecond, and third, compoſe only the ſecond; and the fourth, fifth, and ſixth, compoſe only the fifth; therefore if the ſeventh be added, the ſame effect is produced, as if all the ſeven were employed.

5. Beginning with any colour in the circular ſpectrum, if you take a tint compoſed of a certain proportion of the ſecond and third, (equal in quantity to the firſt, ſecond, third, and fourth,) and add to this the ſixth colour equal in quantity to the fifth, ſixth, and ſeventh, white will be produced.

From theſe curious experiments of Mr. Galton many phenomena in the chemical changes of colours may probably become better underſtood; eſpecially if, as I ſuppoſe, the ſame theory muſt apply to tranſmitted colours, as to reflected ones. Thus it is well known, that if the glaſs of mangoneſe, which is a tint probably compoſed of violet and indigo, be mixed in a certain proportion with the glaſs of lead, which is yellow; that the mixture becomes tranſparent. Now from Mr. Galton's experiments it appears, that in reflected colours ſuch a mixture would produce white, that is, the ſame as if all the colours were reflected. And therefore in tranſmitted colours the ſame circumſtances muſt produce tranſparency, that is, the ſame as if all the colours were tranſmitted. For the particles, which conſtitute the glaſs of mangoneſe will tranſmit red, violet, indigo, and blue; and thoſe of the glaſs of lead will tranſmit orange, yellow, and green; hence all the primary colours by a mixture of theſe glaſſes become tranſmitted, that is, the glaſs becomes tranſparent.

Mr. Galton has further obſerved that five ſucceſſive priſmatic colours may be combined in ſuch proportions as to produce but one colour, a circumſtance which might be of conſequence in the art of painting. For if you begin at any part of the circular ſpectrum above deſcribed, and take the firſt, ſecond, and third colours in the proportions in which they exiſt in the ſpectrum; theſe will compoſe only the ſecond colour equal in quantity to the firſt, ſecond, and third; add to theſe the third, fourth, and fifth in the proportion they exiſt in the ſpectrum, and theſe will produce the fourth colour equal in quantity to the third, fourth, and fifth. Conſequently this is preciſely the ſame thing, as mixing the ſecond and fourth colours only; which mixture would only produce the third colour. Therefore if you combine the firſt, ſecond, fourth, and fifth in the proportions in which they exiſt in the ſpectrum, with double the quantity of the third colour, this third colour will be produced. It is probable that many of the unexpected changes in mixing colours on a painter's eaſle, as well as in more fluid chemical mixtures, may depend on theſe principles rather than on a new arrangement or combination of their minute particles.

Mr. Galton further obſerves, that white may univerſally be produced by the combination of one priſmatic colour, and a tint intermediate to two others. Which tint may be diſtinguiſhed by a name compounded of the two colours, to which it is intermediate. Thus white is produced by a mixture of red with blue-green. Of orange with indigo-blue. Of Yellow with violet-indigo. Of green with red-violet. Of blue with Orange-red. Of indigo with yellow-orange. Of violet with green-yellow. Which he further remarks exactly coincides with the theory and facts mentioned by Dr. Robert Darwin of Shrewſbury in his account of ocular ſpectra; who has ſhewn that when one of theſe contraſted colours has been long viewed, a ſpectrum or appearance of the other becomes viſible in the fatigued eye. Philoſ. Tranſ. Vol. LXXVI. for the year 1786.

Theſe experiments of Mr. Galton might much aſſiſt the copper-plate printers of callicoes and papers in colours; as three colours or more might be produced by two copper-plates. Thus ſuppoſe ſome yellow figures were put on by the firſt plate, and upon ſome parts of theſe yellow figures and on other parts of the ground blue was laid on by another copper-plate: The three colours of yellow, blue, and green might be produced; as green leaves with yellow and blue flowers.

## NOTE III.——COLOURED CLOUDS.

*Eve's ſilken couch with gorgeous tints adorn,*
*Or fire the arrowy throne of riſing morn.*

CANTO I. l. 119.

THE rays from the riſing and ſetting ſun are refracted by our ſpherical atmoſphere, hence the moſt refrangible rays, as the violet, indigo, and blue are reflected in greater quantities from the morning and evening ſkies; and the leaſt refrangible ones, as red and orange, are laſt ſeen about the ſetting ſun. Hence Mr. Beguelin obſerved that the ſhadow of his finger on his pocket-book was much bluer in the morning and evening, when the ſhadow was about eight times as long as the body from which it was projected. Mr. Melville obſerves, that the blue rays being more refrangible are bent down in the evenings by our atmoſphere, while the red and orange being leſs refrangible continue to paſs on and tinge the morning and evening clouds with their colours. See Prieſtley's Hiſtory of Light and Colours, p. 440. But as the particles of air, like thoſe of water, are themſelves blue, a blue ſhadow may be ſeen at all times of the day, though much more beautifully in the mornings and evenings, or by means of a candle in the middle of the day. For if a ſhadow on a piece of white paper is produced by placing your finger between the paper and a candle in the day light, the ſhadow will appear very blue; the yellow light of the candle upon the other parts of the paper apparently deepens the blue by its contraſt; theſe colours being oppoſite to each other, as explained in note II.

Colours are produced from clouds or miſts by refraction, as well as by reflection. In riding in the night over an unequal country I obſerved a very beautiful coloured halo round the moon, whenever I was covered with a few feet of miſt, as I aſcended from the vallies; which ceaſed to appear when I roſe above the miſt. This I ſuppoſe was owing to the thinneſs of the ſtratum of miſt, in which I was immerſed; had it been thicker, the colours refracted by the ſmall drops, of which a fog conſiſts, would not have paſſed through it down to my eye.

There is a bright ſpot ſeen on the cornea of the eye, when we face a window, which is much attended to by portrait painters; this is the light reflected from the ſpherical ſurface of the poliſhed cornea, and brought to a focus; if the obſerver is placed in this focus, he ſees the image of the window; if he is placed before or behind the focus, he only ſees a luminous ſpot, which is more luminous and of leſs extent, the nearer he approaches to the focus. The luminous appearance of the eyes of animals in the duſky corners of a room, or in holes in the earth, may ariſe in ſome inſtances from the ſame principle; viz. the reflection of the light from the ſpherical cornea; which will be coloured red or blue in ſome degree by the morning, evening, or meridian light; or by the objects from which that light is previouſly reflected. In the cavern at Colebrook Dale, where the mineral tar exſudes, the eyes of the horſe, which was drawing a cart from within towards the mouth of it, appeared like two balls of phoſphorus, when he was above 100 yards off, and for a long time before any other part of the animal was viſible. In this caſe I ſuſpect the luminous appearance to have been owing to the light, which had entered the eye, being reflected from the back ſurface of the vitreous humour, and thence emerging again in parallel rays from the animals eye, as it does from the back ſurface of the drops of the rainbow, and from the water-drops which lie, perhaps without contact, on cabbage-leaves, and have the brilliancy of quickſilver. This accounts for this luminous their iris, as in cats and horſes, and is the only part viſible in obſcure places, becauſe this is a better reflecting ſurface than any other of part the animal. If any of theſe emergent rays from the animal's eye can be ſuppoſed to have been reflected from the choroid coat through the ſemi-tranſparent retina, this would account for the coloured glare of the eyes of dogs or cats and rabits in dark corners.

## NOTE IV.—COMETS.

*Alarm with comet-blaze the ſapphire plain,*
*The wan ſtars glimmering through its ſilver train.*
CANTO I. l. 134.

THERE have been many theories invented to account for the tails of comets. Sir Iſaac Newton thinks that they conſiſt of rare vapours raiſed from the nucleus of the comet, and ſo rarefied by the ſun's heat as to have their general gravitation diminiſhed, and that they in conſequence aſcend oppoſite to the ſun, and from thence reflect the rays of light. Dr. Halley compares the light of the tails of comets to the ſtreams of the aurora borealis, and other electric effluvia. Philoſ. Tranſ. No. 347.

Dr. Hamilton obſerves that the light of ſmall ſtars are ſeen undiminiſhed through both the light of the tails of comets, and of the aurora borealis, and has further illuſtrated their electric analogy, and adds that the tails of comets conſiſt of a lucid ſelf-ſhining ſubſtance which has not the power of refracting or reflecting the rays of light. Eſſays.

The tail of the comet of 1744 at one time appeared to extend above 16 degrees from its body, and muſt have thence been above twenty three millions of miles long. And the comet of 1680, according to the calculations of Dr. Halley on November the 11th, was not above one ſemidiameter of the earth, or leſs than 4000 miles to the northward of the way of the earth; at which time had the earth been in that part of its orbit what might have been the conſequence! no one would probably have ſurvived to have regiſtered the tremendous effects.

The comet of 1531, 1607, and 1682 having returned in the year 1759, according to Dr. Halley's prediction in the Philoſ. Tranſ. for 1705, there ſeems no reaſon to doubt that all the other comets will return after their proper periods. Aſtronomers have in general acquieſced in the conjecture of Dr. Halley, that the comets of 1532, and 1661 are one and the ſame comet, from the ſimilarity of the elements of their orbits, and were therefore induced to expect its return to its perihelium in 1789. As this comet is liable to be diſturbed in its aſcent from the ſun by the planets Jupiter and Saturn, Dr. Maſkelyne expected its return to its perihelium in the beginning of the year 1789, or the latter end of the year 1788, and certainly ſometime before the 27th of April, 1789, which prediction has not been fulfilled. Phil. Tranſ. Vol. LXXVI.

## NOTE V.—SUN'S RAYS.

*Or give the ſun's phlogiſtic orb to roll.*

CANTO I. l. 135.

THE diſpute among philoſophers about phlogiſton is not concerning the exiſtence of an inflammable principle, but rather whether there be one or more inflammable principles. The diſciples of Stahl, which till lately included the whole chemical world, believed in the identity of phlogiſton in all bodies which would flame or calcine. The diſciples of Lavoiſier pay homage to a plurality of phlogiſtons under the various names of charcoal, ſulphur, metals, &c. Whatever will unite with *pure* air, and thence compoſe an acid, is eſteemed in this ingenious theory to be a different kind of phlogiſtic or inflammable body. At the ſame time there remains a doubt whether theſe inflammable bodies, as metals, ſulphur, charcoal, &c. may not be compounded of the ſame phlogiſton along with ſome other material yet undiſcovered, and thus an unity of phlogiſton exiſt, as in the theory of Stahl, though very differently applied in the explication of chemical phenomena.

Some modern philoſophers are of opinion that the ſun is the great fountain from which the earth and other planets derive all the phlogiſton which they poſſeſs; and that this is formed by the combination of the ſolar rays with all opake bodies, but particularly with the leaves of vegetables, which they ſuppoſe to be organs adapted to abſorb them. And that as animals receive their nouriſhment from vegetables they alſo obtain in a ſecondary manner their phlogiſton from the ſun. And laſtly as great maſſes of the mineral kingdom, which have been found in the thin cruſt of the earth which human labour has penetrated, have evidently been formed from the recrements of animal and vegetable bodies, theſe alſo are ſuppoſed thus to have derived their phlogiſton from the ſun.

Another opinion concerning the ſun's rays is, that they are not luminous till they arrive at our atmoſphere; and that there uniting with ſome part of the air they produce combuſtion, and light is emitted, and that an etherial acid, yet undiſcovered, is formed from this combuſtion.

The more probable opinion is perhaps, that the ſun is a phlogiſtic maſs of matter, whoſe ſurface is in a ſtate of combuſtion, which like other burning bodies emits light with immenſe velocity in all directions; that theſe rays of light act upon all opake bodies, and combining with them either diſplace or produce their elementary heat, and become chemically combined with the phlogiſtic part of them; for light is given out when phlogiſtic bodies unite with the oxygenous principle of the air, as in combuſtion, or in the reduction of metallic calxes; thus in preſenting to the flame of a candle a letter-wafer, (if it be coloured with red-lead,) at the time the red-lead becomes a metallic drop, a flaſh of light is perceived. Dr. Alexander Wilſon very ingeniouſly endeavours to prove that the ſun is only in a ſtate of combuſtion on its ſurface, and that the dark ſpots ſeen on the diſk are excavations or caverns through the luminous cruſt, ſome of which are 4000 miles in diameter. Phil. Tranſ. 1774. Of this I ſhall have occaſion to ſpeak again.

# NOTE VI.——CENTRAL FIRES.

*Round her ſtill centre thread the burning ſoil,*
*And watch the billowy Lavas, as they boil.*
CANTO I. l. 139.

M. DE MAIRAN in a paper publiſhed in the Hiſtoire de l'Academic de Sciences, 1765, has endeavoured to ſhow that the earth receives but a ſmall part of the heat which it poſſeſſes, from the ſun's rays, but is principally heated by fires within itſelf. He thinks the ſun is the cauſe of the viciſſitudes of our ſeaſons of ſummer and winter by a very ſmall quantity of heat in addition to that already reſiding in the earth, which by emanations from the centre to the circumference renders the ſurface habitable, and without which, though the ſun was conſtantly to illuminate two thirds of the globe at once, with a heat equal to that at the equator, it would ſoon become a maſs of ſolid ice. His reaſonings and calculations on this ſubject are too long and too intricate to be inſerted here, but are equally curious and ingenious and carry much conviction along with them.

The opinion that the center of the earth conſiſts of a large maſs of burning lava, has been eſpouſed by Boyle, Boerhave, and many other philoſophers. Some of whom conſidering its ſuppoſed effects on vegetation and the formation of minerals have called it a ſecond ſun. There are many arguments in ſupport of this opinion. 1. Becauſe the power of the ſun does not extend much beyond ten feet deep into the earth, all below being in winter and ſummer always of the ſame degree of heat, viz. 48, which being much warmer than the mildeſt froſt, is ſuppoſed to be ſuſtained by ſome internal diſtant fire. Add to this however that from experiments made ſome years ago by Dr. Franklin the ſpring-water at Philadelphia appeared to be of 52° of heat, which ſeems further to confirm this opinion, ſince the climates in North America are ſuppoſed to be colder than thoſe of Europe under ſimilar degrees of latitude. 2. Mr. De Luc in going 1359 feet perpendicular into the mines of Hartz on July the 5th, 1778, on a very fine day found the air at the bottom a little warmer that at the top of the ſhaft. Phil. Tranſ. Vol. LXIX. p. 488. In the mines in Hungary, which are 500 cubits deep, the heat becomes very troubleſome when the miners get below 480 feet depth. *Morinus de Locis ſubter.* p. 131. But as ſome other deep mines as mentioned by Mr. Kirwan are ſaid to poſſeſs but the common heat of the earth; and as the cruſt of the globe thus penetrated by human labour is ſo thin compared with the whole, no certain deduction can be made from theſe facts on either ſide of the queſtion. 3. The warm-ſprings in many parts of the earth at great diſtance from any Volcanos ſeem to originate from the condenſation of vapours ariſing from water which is boiled by ſubterraneous fires, and cooled again in their paſſage through a certain length of the colder ſoil; for the theory of chemical ſolution will not explain the equality of their heat at all ſeaſons and through ſo many centuries. See note on Fucus in Vol. II. See a letter on this ſubject in Mr. Pilkinton's View of Derbyſhire from Dr. Darwin. 4. From the ſituations of volcanos which are always found upon the ſummit of the higheſt mountains. For as theſe mountains have been lifted up and loſe ſeveral of their uppermoſt ſtrata as they riſe, the loweſt ſtrata of the earth yet known appear at the tops of the higheſt hills; and the beds of the Volcanos upon theſe hills muſt in conſequence belong to the loweſt ſtrata of the earth, conſiſting perhaps of granite or baſaltes, which were produced before the exiſtence of animal or vegetable bodies, and might conſtitute the original nucleus of the earth, which I have ſuppoſed to have been projected from the ſun, hence the volcanos themſelves appear to be ſpiracula or chimneys belonging to great central fires. It is probably owing to the eſcape of the elaſtic vapours from theſe ſpiracula that the modern earthquakes are of ſuch ſmall extent compared with thoſe of remote antiquity, of which the veſtiges remain all over the globe. 5. The great ſize and height of the continents, and the great ſize and depth of the South-ſea, Atlantic, and other oceans, evince that the firſt earthquakes, which produced theſe immenſe changes in the globe, muſt have been occaſioned by central fires. 6. The very diſtant and expeditious communication of the ſhocks of ſome great earthquakes. The earthquakes at Liſbon in 1755 was perceived in Scotland, in the Peak of Derbyſhire, and in many other diſtant parts of Europe. The percuſſions of it travelled with about the velocity of ſound, viz. about thirteen miles in a minute. The earthquake in 1693 extended 2600 leagues. (Goldſmith's Hiſtory.) Theſe phenomena are eaſily explained if the central parts of the earth conſiſt of a fluid lava, as a percuſſion on one part of ſuch a fluid maſs would be felt on other parts of its confining vault, like a ſtroke on a fluid contained in a bladder, which however gentle on one ſide is perceptible to the hand placed on the other; and the velocity with which ſuch a concuſſion would travel would be that of ſound, or thirteen miles in a minute. For further information on this part of the ſubject the reader is referred to Mr. Michell's excellent Treatiſe on Earthquakes in the Philoſ. Tranſ. Vol. LI. 7. That there is a cavity at the center of the earth is made probable by the late experiments on the attraction of mountains by Mr. Maſkerlyne, who ſuppoſed from other conſiderations that the denſity of the earth near the ſurface ſhould be five times leſs than its mean denſity. Phil. Tranſ. Vol. LXV. p. 498. But found from the attraction of the mountain Schehallien, that it is probable, the mean denſity of the earth is but double that of the hill. Ibid. p. 532. Hence if the firſt ſuppoſition be well founded there would appear to be a cavity at the centre of conſiderable magnitude, from whence the immenſe beds and mountains of lava, toadſtone, baſaltes, granite, &c. have been protruded. 8. The variation of the compaſs can only be accounted for by ſuppoſing the central parts of the earth to conſiſt of a fluid maſs, and that part of this fluid is iron, which requiring a greater degree of heat to bring it into fuſion than glaſs or other metals, remains a ſolid, and the vis inertiæ of this fluid maſs with the iron in it, occaſions it to perform fewer revolutions than the cruſt of ſolid earth over it, and thus it is gradually left behind, and the place where the floating iron reſides is pointed to by the direct or retrograde motions of the magnetic needle. This ſeems to have been nearly the opinion of Dr. Halley and Mr. Euler.

## NOTE VII.—ELEMENTARY HEAT.

*Or ſphere on ſphere in widening waves expand,*
*And glad with genial warmth the incumbent land.*
Canto I. l. 143.

A CERTAIN quantity of heat ſeems to be combined with all bodies beſides the ſenſible quantity which gravitates like the electric fluid amongſt them. This combined heat or latent heat of Dr. Black, when ſet at liberty by fermentation, inflammation, cryſtallization, freezing, or other chemical attractions producing new *combinations*, paſſes as a fluid element into the ſurrounding bodies. And by thawing, diffuſion of neutral ſalts in water, melting, and other chemical *ſolutions*, a portion of heat is attracted from the bodies in vicinity and enters into or becomes combined with new ſolutions.

Hence a *combination* of metals with acids, of eſſential oils and acids, of alcohol and water, of acids and water, give out heat; whilſt a *ſolution* of ſnow in water or in acids, and of neutral ſalts in water, attract heat from the ſurrounding bodies. So the acid of nitre mixed with oil of cloves unites with it and produces a moſt violent flame; the ſame acid of nitre poured on ſnow inſtantly diſſolves it and produces the greateſt degree of cold yet known, by which at Peterſburgh quickſilver was firſt frozen in 1760.

Water may be cooled below 32° without being frozen, if it be placed on a ſolid floor and ſecured from agitation, but when thus cooled below the freezing point the leaſt agitation turns part of it ſuddenly into ice, and when this ſudden freezing takes place a thermometer placed in it inſtantly riſes as ſome heat is given out in the act of congelation, and the ice is thus left with the ſame *ſenſible* degree of cold as the water had poſſeſſed before it was agitated, but is nevertheleſs now combined with leſs *latent* heat.

A cubic inch of water thus cooled down to 32° mixed with an equal quantity of boiling water at 212° will cool it to the middle number between theſe two, or to 122. But a cubic inch of ice whoſe ſenſible cold alſo is but 32, mixed with an equal quantity of boiling water, will cool it ſix times as much as the cubic inch of cold water above-mentioned, as the ice not only gains its ſhare of the ſenſible or gravitating heat of the boiling water, but attracts to itſelf alſo and combines with the quantity of latent heat which it had loſt at the time of its congelation.

So boiling water will acquire but 212° of heat under the common preſſure of the atmoſphere, but the ſteam raiſed from it by its expanſion or by its ſolution in the atmoſphere combines with and carries away a prodigious quantity of heat which it again parts with on its condenſation; as is ſeen in common diſtillation where the large quantity of water in the worm-tub is ſo ſoon heated. Hence the evaporation of ether on a thermometer ſoon ſinks the mercury below freezing, and hence a warmth of the air in winter frequently ſucceeds a ſhower.

When the matter of heat or calorique is ſet at liberty from its combinations, as by inflammation, it paſſes into the ſurrounding bodies, which poſſeſs different capacities of acquiring their ſhare of the looſe or ſenſible heat; thus a pint meaſure of cold water at 48° mixed with a pint of boiling water at 212° will cool it to the degree between theſe two numbers, or to 154°, but it requires two pint meaſures of quickſilver at 48° of heat to cool one pint of water as above. Theſe and other curious experiments are adduced by Dr. Black to evince the exiſtence of combined or latent heat in bodies, as has been explained by ſome of his pupils, and well illuſtrated by Dr. Crawford. The world has long been in expectation of an account of his diſcoveries on this ſubject by the celebrated author himſelf.

As this doctrine of elementary heat in its fluid and combined ſtate is not yet univerſally received, I ſhall here add two arguments in ſupport of it drawn from different ſources, viz. from the heat given out or abſorbed by the mechanical condenſation or expanſion of the air, and perhaps of other bodies, and from the analogy of the various phenomena of heat with thoſe of electricity.

I. If a thermometer be placed in the receiver of an air-pump, and the air haſtily exhauſted, the thermometer will ſink ſome degrees, and the glaſs become ſteamy; the ſame occurs in haſtily admitting a part of the air again. This I ſuppoſe to be produced by the expanſion of part of the air, both during the exhauſtion and re-admiſſion of it; and that the air ſo expanded becomes capable of attracting from the bodies in its vicinity a part of their heat, hence the vapours contained in it and the glaſs receiver are for a time colder and the ſteam is precipitated. That the air thus parts with its moiſture from the cold occaſioned by its rarefaction and not ſimply by the rarefaction itſelf is evident, becauſe in a minute or two the ſame rarefied air will again take up the dew depoſited on the receiver; and becauſe water will evaporate ſooner in rare than in denſe air.

There is a curious phenomenon ſimilar to this obſerved in the fountain of Hiero conſtructed on a large ſcale at the Chemnicenſian mines in Hungary. In this machine the air in a large veſſel is compreſſed by a column of water 260 feet high, a ſtop-cock is then opened, and as the air iſſues out with great vehemence, and thus becomes immediately greatly expanded, ſo much cold is produced that the moiſture from this ſtream of air is precipitated in the form of ſnow, and ice is formed adhering to the noſel of the cock. This remarkable circumſtance is deſcribed at large with a plate of the machine in Philoſ. Tranſ. Vol. LII. for 1761.

The following experiment is related by Dr. Darwin in the Philoſ. Tranſ. Vol. LXXVIII. Having charged an air-gun as forcibly as he well could, the air-cell and ſyringe became exceedingly hot, much more ſo than could be aſcribed to the friction in working it; it was then left about half an hour to cool down to the temperature of the air, and a thermometer having been previouſly fixed againſt a wall, the air was diſcharged in a continual ſtream on its bulb, and it ſunk many degrees. From theſe three experiments of the ſteam in the exhauſted receiver being depoſited and re-abſorbed, when a part of the air is exhauſted or re-admitted, and the ſnow produced by the fountain of Hiero, and the extraordinary heat given out in charging, and the cold produced in diſcharging an air-gun, there is reaſon to conclude that when air is mechanically compreſſed the elementary fluid heat is preſſed out of it, and that when it is mechanically expanded the ſame fluid heat is re-abſorbed from the common maſs.

It is probable all other bodies as well as air attract heat from their neighbours when they are mechanically expanded, and give it out when they are mechanically condenſed. Thus when a vibration of the particles of hard bodies is excited by friction or by percuſſion, theſe particles mutually recede from and approach each other reciprocally; at the times of their receſſion from each other, the body becomes enlarged in bulk, and is then in a condition to attract heat from thoſe in its vicinity with great and ſudden power; at the times of their approach to each other this heat is again given out, but the bodies in contact having in the mean while received the heat they had thus loſt, from other bodies behind them, do not ſo ſuddenly or ſo forcibly re-abſorb the heat again from the body in vibration; hence it remains on its ſurface like the electric fluid on a rubbed glaſs globe, and for the ſame reaſon, becauſe there is no good conductor to take it up again. Hence at every vibration more and more heat is acquired and ſtands looſe upon the ſurface; as in filing metals or rubbing glaſs tubes; and thus a ſmith with a few ſtrokes on a nail on his anvil can make it hot enough to light a brimſtone-match; and hence in ſtriking flint and ſteel together heat enough is produced to vitrify the parts thus ſtrucken off, the quantity of which heat is again probably increaſed by the new chemical combination.

II. The analogy between the phenomena of the electric fluid and of heat furniſhes another argument in ſupport of the exiſtence of heat as a gravitating fluid. 1. They are both accumulated by friction on the excited body. 2. They are propagated eaſily or with difficulty along the ſame claſſes of bodies, with eaſe by metals, with leſs eaſe by water; and with difficulty by reſins, bees-wax, ſilk, air, and glaſs. Thus glaſs canes or canes of ſealing-wax may be melted by a blow-pipe or a candle within a quarter of an inch of the fingers which hold them, without any inconvenient heat, while a pin or other metallic ſubſtance applyed to the flame of a candle ſo readily conducts the heat as immediately to burn the fingers. Hence clothes of ſilk keep the body warmer than clothes of linen of equal thickneſs, by confining the heat upon the body. And hence plains are ſo much warmer than the ſummits of mountains by the greater denſity of the air confining the acquired heat upon them.

3. They both give out light in their paſſage through air, perhaps not in their paſſage through a vacuum. 4. They both of them fuſe or vitrify metals. 5. Bodies after being electrized if they are mechanically extended will receive a greater quantity of electricity, as in Dr. Franklin's experiment of the chain in the tankard; the ſame ſeems true in reſpect to heat as explained above. 6. Both heat and electricity contribute to ſuſpend ſteam in the atmoſphere by producing or increaſing the repulſion of its particles. 7. They both gravitate, when they have been accumulated, till they find their equilibrium.

If we add to the above the many chemical experiments which receive an eaſy and elegant explanation from the ſuppoſed matter of heat, as employed in the works of Bergman and Lavoiſier, I think we may reaſonably allow of its exiſtence as an element, occaſionally combined with other bodies, and occaſionally exiſting as a fluid, like the electric fluid gravitating amongſt them. And that hence it may be propagated from the central fires of the earth to the whole maſs, and contribute to preſerve the mean heat of the earth, which in this country is about 48 degrees but variable from the greater or leſs effect of the ſun's heat in different climates, ſo well explained in Mr. Kirwan's Treatiſe on the Temperature of different Latitudes. 1787, Elmſly. London.

## NOTE VIII.—MEMNON'S LYRE.

*So to the ſacred Sun in Memnon's fane*
*Spontaneous concords quired the matin ſtrain.*

CANTO I. l. 181.

THE gigantic ſtatue of Memnon in his temple at Thebes had a lyre in his hands, which many credible writers aſſure us, ſounded when the riſing ſun ſhone upon it. Some philoſophers have ſuppoſed that the ſun's light poſſeſſes a mechanical impulſe, and that the ſounds abovementioned might be thence produced. Mr. Michell conſtructed a very tender horizontal balance, as related by Dr. Prieſtley in his hiſtory of light and colours, for this purpoſe, but ſome experiments with this balance which I ſaw made by the late Dr. Powel, who threw the focus of a large reflector on one extremity of it, were not concluſive eitherway, as the copper leaf of the balance approached in one experiment and receded in another.

There are however methods by which either a rotative or alternating motion may be produced by very moderate degrees of heat. If a ſtraight glaſs tube, ſuch as are uſed for barometers, be ſuſpended horizontally before a fire, like a roaſting ſpit, it will revolve by intervals; for as glaſs is a bad conductor of heat the ſide next the fire becomes heated ſooner than the oppoſite ſide, and the tube becomes bent into a bow with the external part of the curve towards the fire, this curve then falls down and produces a fourth part of a revolution of the glaſs tube, which thus revolves with intermediate pauſes.

Another alternating motion I have ſeen produced by ſuſpending a glaſs tube about eight inches long with bulbs at each end on a centre like a ſcale beam. This curious machine is filled about one third part with pureſt ſpirit of wine, the other two thirds being a vacuum, and is called a pulſe-glaſs, if it be placed in a box before the fire, ſo that either bulb, as it riſes, may become ſhaded from the fire, and expoſed to it when it deſcends, an alternate libration of it is produced. For ſpirit of wine in vacuo emits ſteam by a very ſmall degree of heat, and this ſteam forces the ſpirit beneath it up into the upper bulb, which therefore deſcends. It is probable ſuch a machine on a larger ſcale might be of uſe to open the doors or windows of hot-houſes or melon-frames, when the air within them ſhould become too much heated, or might be employed in more important mechanical purpoſes.

On travelling through a hot ſummer's day in a chaiſe with a box covered with leather on the fore-axle-tree, I obſerved, as the ſun ſhone upon the black leather, the box began to open its lid, which at noon roſe above a foot, and could not without great force be preſſed down; and which gradually cloſed again as the ſun declined in the evening. This I ſuppoſe might with ſtill greater facility be applied to the purpoſe of opening melon-frames or the ſaſhes of hot-houſes.

The ſtatue of Memnon was overthrown and ſawed in two by Cambyſes to diſcover its internal ſtructure, and is ſaid ſtill to exiſt. See Savary's Letters on Egypt. The truncated ſtatue is ſaid for many centuries to have ſaluted the riſing ſun with chearful tones, and the ſetting ſun with melancholy ones.

## NOTE IX.——LUMINOUS INSECTS.

*Star of the earth, and diamond of the night.*
CANTO I. l. 192.

THERE are eighteen ſpecies of Lampyris or glow-worm, according to Linneus, ſome of which are found in almoſt every part of the world. In many of the ſpecies the females have no wings, and are ſuppoſed to be diſcovered by the winged males by their ſhining in the night. They become much more lucid when they put themſelves in motion, which would ſeem to indicate that their light is owing to their reſpiration; in which proceſs it is probable phoſphoric acid is produced by the combination of vital air with ſome part of the blood, and that light is given out through their tranſparent bodies by this ſlow internal combuſtion.

There is a fire-fly of the beetle-kind deſcribed in the Dict. Raiſonné under the name of Acudia, which is ſaid to be two inches long, and inhabits the Weſt-Indies and South America; the natives uſe them inſtead of candles, putting from one to three of them under a glaſs. Madam Merian ſays, that at Surinam the light of this fly is ſo great, that ſhe ſaw ſufficiently well by one of them to paint and finiſh one of the figures of them in her work on inſects. The largeſt and oldeſt of them are ſaid to become four inches long, and to ſhine like a ſhooting ſtar as they fly, and are thence called Lantern-bearers. The uſe of this light to the inſect itſelf ſeems to be that it may not fly againſt objects in the night; by which contrivance theſe inſects are enabled to procure their ſuſtenance either by night or day, as their wants may require, or their numerous enemies permit them; whereas ſome of our beetles have eyes adapted only to the night, and if they happen to come abroad too ſoon in the evening are ſo dazzled that they fly againſt every thing in their way. See note on Phoſphorus, No. X.

In ſome ſeas, as particularly about the coaſt of Malabar, as a ſhip floats along, it ſeems during the night to be ſurrounded with fire, and to leave a long tract of light behind it. Whenever the ſea is gently agitated it ſeems converted into little ſtars, every drop as it breaks emits light, like bodies electrified in the dark. Mr. Bomare ſays, that when he was at the port of Cettes in Languedoc, and bathing with a companion in the ſea after a very hot day, they both appeared covered with fire after every immerſion, and that laying his wet hand on the arm of his companion, who had not then dipped himſelf, the exact mark of his hand and fingers was ſeen in characters of fire. As numerous microſcopic inſects are found in this ſhining water, its light has been generally aſcribed to them, though it ſeems probable that fiſh-ſlime in hot countries may become in ſuch a ſtate of incipient putrefaction as to give light, eſpecially when by agitation it is more expoſed to the air; otherwiſe it is not eaſy to explain why agitation ſhould be neceſſary to produce this marine light. See note on Phoſphorus No. X.

# NOTE X.—PHOSPHORUS.

*Or mark in ſhining letters Kunckel's name*
*In the pale phoſphor's ſelf-conſuming flame.*

CANTO I. l. 237.

KUNCKEL, a native of Hamburgh, was the firſt who diſcovered to the world the proceſs for producing phoſphorus; though Brandt and Boyle were likewiſe ſaid to have previouſly had the art of making it. It was obtained from ſal microcoſmicum by evaporation in the form of an acid, but has ſince been found in other animal ſubſtances, as in the aſhes of bones, and even in ſome vegetables, as in wheat flour. Keir's chemical Dict. This phoſphoric acid is like all other acids united with vital air, and requires to be treated with charcoal or phlogiſton to deprive it of this air, it then becomes a kind of animal ſulphur, but of ſo inflammable a nature, that on the acceſs of air it takes fire ſpontaneouſly, and as it burns becomes again united with vital air, and re-aſſumes its form of phoſphoric acid.

As animal reſpiration ſeems to be a kind of ſlow combuſtion, in which it is probable that phoſphoric acid is produced by the union of phoſphorus with the vital air, ſo it is alſo probable that phoſphoric acid is produced in the excretory or reſpiratory veſſels of luminous inſects, as the glow-worm and fire-fly, and ſome marine inſects. From the ſame principle I ſuppoſe the light from putrid fiſh, as from the heads of haddocks, and from putrid veal, and from rotten wood in a certain ſtate of their putrefaction, is produced, and phoſphorus thus ſlowly combined with air is changed into phoſphoric acid. The light from the Bolognian ſtone, and from calcined ſhells, and from white paper, and linen after having been expoſed for a time to the ſun's light, ſeem to produce either the phoſphoric or ſome other kind of acid from the ſulphurous or phlogiſtic matter which they contain. See note on Beccari's ſhells. l. 180.

There is another proceſs ſeems ſimilar to this ſlow combuſtion, and that is *bleaching*. By the warmth and light of the ſun the water ſprinkled upon linen or cotton cloth ſeems to be decompoſed, (if we credit the theory of M. Lavoiſier,) and a part of the vital air thus ſet at liberty and uncombined and not being in its elaſtic form, more eaſily diſſolves the colouring or phlogiſtic matter of the cloth, and produces a new acid, which is itſelf colourleſs, or is waſhed out of the cloth by water. The new proceſs of bleaching confirms a part of this theory, for by uniting much vital air to marine acid by diſtilling it from manganeſe, on dipping the cloth to be bleached in water repleat with this ſuperaerated marine acid, the colouring matter diſappears immediately, ſooner indeed in cotton than in linen. See note XXXIV.

There is another proceſs which I ſuſpect bears analogy to theſe abovementionned, and that is the rancidity of animal fat, as of bacon; if bacon be hung up in a warm kitchen, with much ſalt adhering on the outſide of it, the fat part of it ſoon becomes yellow and rancid; if it be waſhed with much cold water after it has imbibed the ſalt, and juſt before it is hung up, I am well informed, that it will not become rancid, or in very ſlight degrees. In the former caſe I imagine the ſalt on the ſurface of the bacon attracts water during the cold of the night, which is evaporated during the day, and that in this evaporation a part of the water becomes decompoſed, as in bleaching, and its vital air uniting with greater facility in its unelaſtic ſtate with the animal fat, produces an acid, perhaps of the phoſphoric kind, which being of a fixed nature lies upon the bacon, giving it the yellow colour and rancid taſte. It is remarkable that the ſuperaerated marine acid does not bleach living animal ſubſtances, at leaſt it did not whiten a part of my hand which I for ſome minutes expoſed to it.

## NOTE XI.——STEAM-ENGINE.

*Quick moves the balanced beam, of giant-birth,*
*Wields his large limbs, and nodding ſhakes the earth.*
CANTO I. l. 267.

THE expanſive force of ſteam was known in ſome degree to the antients, Hero of Alexandria deſcribes an application of it to produce a rotative motion by the re-action of ſteam iſſuing from a ſphere mounted upon an axis, through two ſmall tubes bent into tangents, and iſſuing from the oppoſite ſides of the equatorial diameter of the ſphere, the ſphere was ſupplied with ſteam by a pipe communicating with a pan of boiling water, and entering the ſphere at one of its poles.

A french writer about the year 1630 deſcribes a method of raiſing water to the upper part of a houſe by filling a chamber with ſteam, and ſuffering it to condenſe of itſelf, but it ſeems to have been mere theory, as his method was ſcarcely practicable as he deſcribes it. In 1655 the Marquis of Worceſter mentions a method of raiſing water by fire in his Century of Inventions, but he ſeems only to have availed himſelf of the expanſive force and not to have known the advantages ariſing from condenſing the ſteam by an injection of cold water. This latter and moſt important improvement ſeems to have been made by Capt. Savery ſometime prior to 1698, for in that year his patent for the uſe of that invention was confirmed by act of parliament. This gentleman appears to have been the firſt who reduced the machine to practice and exhibited it in an uſeful form. This method conſiſted only in expelling the air from a veſſel by ſteam and condenſing the ſteam by an injection of cold water, which making a vacuum, the preſſure of the atmoſphere forced the water to aſcend into the ſteam-veſſel through a pipe of 24 to 26 feet high, and by the admiſſion of denſe ſteam from the boiler, forcing the water in the ſteam-veſſel to aſcend to the height deſired. This conſtruction was defective becauſe it required very ſtrong veſſels to reſiſt the force of the ſteam, and becauſe an enormous quantity of ſteam was condenſed by coming in contact with the cold water in the ſteam-veſſel.

About or ſoon after that time M. Papin attempted a ſteam-engine on ſimilar principles but rather more defective in its conſtruction.

The next improvement was made very ſoon afterwards by Meſſrs. Newcomen and Cawley of Dartmouth, it conſiſted in employing for the ſteam-veſſel a hollow cylinder, ſhut at bottom and open at top, furniſhed with a piſton ſliding eaſily up and down in it, and made tight by oakum or hemp, and covered with water. This piſton is ſuſpended by chains from one end of a beam, moveable upon an axis in the middle of its length, to the other end of this beam are ſuſpended the pump-rods.

The danger of burſting the veſſels was avoided in this machine, as however high the water was to be raiſed it was not neceſſary to increaſe the denſity of the ſteam but only to enlarge the diameter of the cylinder.

Another advantage was, that the cylinder not being made ſo cold as in Savary's method, much leſs ſteam was loſt in filling it after each condenſation.

The machine however ſtill remained imperfect, for the cold water thrown into the cylinder acquired heat from the ſteam it condenſed, and being in a veſſel exhauſted of air it produced ſteam itſelf, which in part reſiſted the action of the atmoſphere on the piſton; were this remedied by throwing in more cold water the deſtruction of ſteam in the next filling of the cylinder would be proportionably increaſed. It has therefore in practice been found adviſeable not to load theſe engines with columns of water weighing more than ſeven pounds for each ſquare inch of the area of the piſton. The bulk of water when converted into ſteam remained unknown until Mr. J. Watt, then of Glaſgow, in 1764, determined it to be about 1800 times more rare than water. It ſoon occurred to Mr. Watt that a perfect engine would be that in which no ſteam ſhould be condenſed in filling the cylinder, and in which the ſteam ſhould be ſo perfectly cooled as to produce nearly a perfect vacuum.

Mr. Watt having aſcertained the degree of heat in which water boiled in vacuo, and under progreſſive degrees of preſſure, and inſtructed by Dr. Black's diſcovery of latent heat, having calculated the quantity of cold water neceſſary to condenſe certain quantities of ſteam ſo far as to produce the exhauſtion required, he made a communication from the cylinder to a cold veſſel previouſly exhauſted of air and water, into which the ſteam ruſhed by its elaſticity, and became immediately condenſed. He then adapted a cover to the cylinder and admitted ſteam above the piſton to preſs it down inſtead of air, and inſtead of applying water he uſed oil or greaſe to fill the pores of the oakum and to lubricate the cylinder.

He next applied a pump to extract the injection water, the condenſed ſteam, and the air, from the condenſing veſſel, every ſtroke of the engine.

To prevent the cooling of the cylinder by the contact of the external air, he ſurrounded it with a caſe containing ſteam, which he again protected by a covering of matters which conduct heat ſlowly.

This conſtruction preſented an eaſy means of regulating the power of the engine, for the ſteam being the acting power, as the pipe which admits it from the boiler is more or leſs opened, a greater or ſmaller quantity can enter during the time of a ſtroke, and conſequently the engine can act with exactly the neceſſary degree of energy.

Mr. Watt gained a patent for his engine in 1768, but the further perſecution of his deſigns were delayed by other avocations till 1775, when in conjunction with Mr. Boulton of Soho near Birmingham, numerous experiments were made on a large ſcale by their united ingenuity, and great improvements added to the machinery, and an act of parliament obtained for the prolongation of their patent for twenty-five years, they have ſince that time drained many of the deep mines in Cornwall, which but for the happy union of ſuch genius muſt immediately have ceaſed to work. One of theſe engines works a pump of eighteen inches diameter, and upwards of 100 fathom or 600 feet high, at the rate of ten to twelve ſtrokes of ſeven feet long each, in a minute, and that with one-fifth part of the coals which a common engine would have taken to do the ſame work. The power of this engine may be eaſier comprehended by ſaying that it raiſed a weight equal to 81000 pounds 80 feet high in a minute, which is equal to the combined action of 200 good horſes. In Newcomen's engine this would have required a cylinder of the enormous diameter of 120 inches or ten feet, but as in this engine of Mr. Watt and Mr. Boulton the ſteam acts, and a vacuum is made, alternately above and below the piſton, the power exerted is double to what the ſame cylinder would otherways produce, and is further augmented by an inequality in the length of the two ends of the lever.

Theſe gentlemen have alſo by other contrivances applied their engines to the turning of mills for almoſt every purpoſe, of which that great pile of machinery the Albion Mill is a well known inſtance. Forges, ſlitting mills, and other great works are erected where nature has furniſhed no running water, and future times may boaſt that this grand and uſeful engine was invented and perfected in our own country.

Since the above article went to the preſs the Albion Mill is no more; it is ſuppoſed to have been ſet on fire by intereſted or malicious incendiaries, and is burnt to the ground. Whence London has loſt the credit and the advantage of poſſeſſing the moſt powerful machine in the world!

## NOTE XII.——FROST.

*In phalanx firm the fiend of Froſt aſſail.*

CANTO I. l. 446.

THE cauſe of the expanſion of water during its converſion into ice is not yet well aſcertained, it was ſuppoſed to have been owing to the air being ſet at liberty in the act of congelation which was before diſſolved in the water, and the many air bubbles in ice were thought to countenance this opinion. But the great force with which ice expands during its congelation, ſo as to burſt iron bombs and coehorns, according to the experiments of Major Williams at Quebec, invalidates this idea of the cauſe of it, and may ſometime be brought into uſe as a means of breaking rocks in mining, or projecting cannon-balls, or for other mechanical purpoſes, if the means of producing congelation ſhould ever be diſcovered to be as eaſy as the means of producing combuſtion.

Mr. de Mairan attributes the increaſe of bulk of frozen water to the different arrangement of the particles of it in cryſtallization, as they are conſtantly joined at an angle of 60 degrees; and muſt by this diſpoſition he thinks occupy a greater volume than if they were parallel. He found the augmentation of the water during freezing to amount to one-fourteenth, one-eighteenth, one-nineteenth, and when the water was previouſly purged of air to only one-twenty-ſecond part. He adds that a piece of ice, which was at firſt only one-fourteenth part ſpecifically lighter than water, on being expoſed ſome days to the froſt became one-twelfth lighter than water. Hence he thinks ice by being expoſed to greater cold ſtill increaſes in volume, and to this attributes the burſting of ice in ponds and on the glaciers. See Lewis's Commerce of Arts, p. 257. and the note on Muſchus in the other volume of this work.

This expanſion of ice well accounts for the greater miſchief done by vernal froſts attended with moiſture, (as by hoar-froſts,) than by the dry froſts called black froſts. Mr. Lawrence in a letter to Mr. Bradley complains that the dale-miſt attended with a froſt on May-day had deſtroyed all his tender fruits; though there was a ſharper froſt the night before without a miſt, that did him no injury; and adds, that a garden not a ſtone's throw from his own on a higher ſituation, being above the dale-miſt, had received no damage. Bradley, Vol. II. p. 232.

Mr. Hunter by very curious experiments diſcovered that the living principle in fiſh, in vegetables, and even in eggs and ſeeds, poſſeſſes a power of reſiſting congelation. Phil. Tranſ. There can be no doubt but that the exertions of animals to avoid the pain of cold may produce in them a greater quantity of heat, at leaſt for a time, but that vegetables, eggs, or ſeeds, ſhould poſſeſs ſuch a quality is truly wonderful. Others have imagined that animals poſſeſs a power of preventing themſelves from becoming much warmer than 98 degrees of heat, when immerſed in an atmoſphere above that degree of heat. It is true that the increaſed exhalation from their bodies will in ſome meaſure cool them, as much heat is carried off by the evaporation of fluids, but this is a chemical not an animal proceſs. The experiments made by thoſe who continued many minutes in the air of a room heated ſo much above any natural atmoſpheric heat, do not ſeem concluſive, as they remained in it a leſs time than would have been neceſſary to have heated a maſs of beef of the ſame magnitude, and the circulation of the blood in living animals, by perpetually bringing new ſupplies of fluid to the ſkin, would prevent the external ſurface from becoming hot much ſooner than the whole maſs. And thirdly, there appears no power of animal bodies to produce cold in diſeaſes, as in ſcarlet fever, in which the increaſed action of the veſſels of the ſkin produces heat and contributes to exhauſt the animal power already too much weakened.

It has been thought by many that froſts meliorate the ground, and that they are in general ſalubrious to mankind. In reſpect to the former it is now well known that ice or ſnow contain no nitrous particles, and though froſt by enlarging the bulk of moiſt clay leaves it ſofter for a time after the thaw, yet as ſoon as the water exhales, the clay becomes as hard as before, being preſſed together by the incumbent atmoſphere, and by its ſelf-attraction, called *ſetting* by the potters. Add to this that on the coaſts of Africa, where froſt is unknown, the fertility of the ſoil is almoſt beyond our conceptions of it. In reſpect to the general ſalubrity of froſty ſeaſons the bills of mortality are an evidence in the negative, as in long froſts many weakly and old people periſh from debility occaſioned by the cold, and many claſſes of birds and other wild animals are benumbed by the cold or deſtroyed by the conſequent ſcarcity of food, and many tender vegetables periſh from the degree of cold.

I do not think it ſhould be objected to this doctrine that there are moiſt days attended with a briſk cold wind when no viſible ice appears, and which are yet more diſagreeable and deſtructive than froſty weather. For on theſe days the cold moiſture, which is depoſited on the ſkin is there evaporated and thus produces a degree of cold perhaps greater than the milder froſts. Whence even in ſuch days both the diſagreeable ſenſations and inſalubrious effects belong to the cauſe above mentioned, viz. the intenſity of the cold. Add to this that in theſe cold moiſt days as we paſs along or as the wind blows upon us, a new ſheet of cold water is as it were perpetually applied to us and hangs upon our bodies, now as water is 800 times denſer than air and is a much better conductor of heat, we are ſtarved with cold like thoſe who go into a cold bath, both by the great number of particles in contact with the ſkin and their greater facility of receiving our heat.

It may nevertheleſs be true that ſnows of long duration in our winters may be leſs injurious to vegetation than great rains and ſhorter froſts, for two reaſons. 1. Becauſe great rains carry down many thouſand pounds worth of the beſt part of the manure off the lands into the ſea, whereas ſnow diſſolves more gradually and thence carries away leſs from the land; any one may diſtinguiſh a ſnow-flood from a rain-flood by the tranſparency of the water. Hence hills or fields with conſiderable inclination of ſurface ſhould be ploughed horizontally that the furrows may ſtay the water from ſhowers till it depoſits its mud. 2. Snow protects vegetables from the ſeverity of the froſt, ſince it is always in a ſtate of thaw where it is in contact with the earth; as the earth's heat is about 48° and the heat of thawing ſnow is 32° the vegetables between them are kept in a degree of heat about 40, by which many of them are preſerved. See note on Muſchus, Vol. II. of this work.

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## NOTE XIII.——ELECTRICITY.

*Cold from each point celurean luſtres gleam.*

Canto I. l. 345.

## ELECTRIC POINTS.

THERE was an idle diſpute whether knobs or points were preferable on the top of conductors for the defence of houſes. The deſign of theſe conductors is to permit the electric matter accumulated in the clouds to paſs through them into the earth in a ſmaller continued ſtream as the cloud approaches, before it come to what is termed ſtriking diſtance; now as it is well known that accumulated electricity will paſs to points at a much greater diſtance than it will to knobs there can be no doubt of their preference; and it would ſeem that the finer the point and the leſs liable to become ruſty the better, as it would take off the lightening while it was ſtill at a greater diſtance, and by that means preſerve a greater extent of building; the very extre- mity of the point ſhould be of pure ſilver or gold, and might be branched into a kind of bruſh, ſince one ſmall point can not be ſuppoſed to receive ſo great a quantity as a thicker bar might conduct into the earth.

If an inſulated metallic ball is armed with a point, like a needle, projecting from one part of it, the electric fluid will be ſeen in the dark to paſs off from this point, ſo long as the ball is kept ſupplied with electricity. The reaſon of this is not difficult to comprehend, every part of the electric atmoſphere which ſurrounds the inſulated ball is attracted to that ball by a large ſurface of it, whereas the electric atmoſphere which is near the extremity of the needle is attracted to it by only a ſingle point, in conſequence the particles of electric matter near the ſurface of the ball approach towards it and puſh off by their greater gravitation the particles of electric matter over the point of the needle in a continued ſtream.

Something like this happens in reſpect to the diffuſion of oil on water from a pointed cork, an experiment which was many years ago ſhewn me by Dr. Franklin; he cut a piece of cork about the ſize of a letter-wafer and left on one edge of it a point about a ſixth of an inch in length projecting as a tangent to the circumference. This was dipped in oil and thrown on a pond of water and continued to revolve as the oil left the point for a great many minutes. The oil deſcends from the floating cork upon the water being diffuſed upon it without friction and perhaps without contact; but its going off at the point ſo forcibly as to make the cork revolve in a contrary direction ſeems analogous to the departure of the electric fluid from points.

Can any thing ſimilar to either of theſe happen in reſpect to the earth's atmoſphere and give occaſion to the breezes on the tops of mountains, which may be conſidered as points on the earth's circumference?

## FAIRY-RINGS.

There is a phenomenon ſuppoſed to be electric which is yet unaccounted for, I mean the Fairy-rings, as they are called, ſo often ſeen on the graſs. The numerous flaſhes of lightning which occur every ſummer are, I believe, generally diſcharged on the earth, and but ſeldom (if ever) from one cloud to another. Moiſt trees are the moſt frequent conductors of theſe flaſhes of lightning, and I am informed by purchaſers of wood that innumerable trees are thus cracked and injured. At other times larger parts or prominences of clouds gradually ſinking as they move along, are diſcharged on the moiſture parts of graſſy plains. Now this knob or corner of a cloud in being attracted by the earth will become nearly cylindrical, as looſe wool would do when drawn out into a thread, and will ſtrike the earth with a ſtream of electricity perhaps two or ten yards in diameter. Now as a ſtream of electricity diſplaces the air it paſſes through, it is plain no part of the graſs can be burnt by it, but juſt the external ring of this cylinder where the graſs can have acceſs to the air, ſince without air nothing can be calcined. This earth after having been ſo calcined becomes a richer ſoil, and either funguſes or a bluer graſs for many years mark the place. That lightening diſplaces the air in its paſſage is evinced by the loud crack that ſucceeds it, which is owing to the ſides of the aerial vacuum clapping together when the lightning is withdrawn. That nothing will calcine without air is now well underſtood from the acids produced in the burning of phlogiſtic ſubſtances, and may be agreeably ſeen by ſuſpending a paper on an iron prong and putting it into the centre of the blaze of an iron-furnace; it may be held there ſome ſeconds and may be again withdrawn without its being burnt, if it be paſſed quickly into the flame and out again through the external part of it which is in contact with the air. I know ſome circles of many yards diameter of this kind near Foremark in Derbyſhire, which annually produce large white funguſes and ſtronger graſs, and have done ſo, I am informed, above thirty years. This increaſed fertility of the ground by calcination or charring, and its continuing to operate ſo many years is well worth the attention of the farmer, and ſhews the uſe of paring and burning new turf in agriculture, which produces its effect not ſo much by the aſhes of the vegetable fibres as by charring the ſoil which adheres to them.

Theſe ſituations, whether from eminence or from moiſture, which were proper once to attract and diſcharge a thunder-cloud, are more liable again to experience the ſame. Hence many fairy-rings are often ſeen near each other either without interſecting each other, as I ſaw this ſummer in a garden in Nottinghamſhire, or interſecting each other as deſcribed on Arthur's ſeat near Edinburgh in the Edinb. Tranſ. Vol. II. p. 3.

## NOTE XIV.——BUDS AND BULBS.

*Where dwell my vegetative realms benumb'd*
*In buds impriſon'd, or in bulbs intombed.*

CANTO I. l. 465.

A TREE is properly ſpeaking a family or ſwarm of buds, each bud being an individual plant, for if one of theſe buds be torn or cut out and planted in the earth with a glaſs cup inverted over it to prevent its exhalation from being at firſt greater than its power of abſorption, it will produce a tree ſimilar to its parent; each bud has a leaf, which is its lungs, appropriated to it, and the bark of the tree is a congeries of the roots of theſe individual buds, whence old hollow trees are often ſeen to have ſome branches flouriſh with vigour after the internal wood is almoſt intirely decayed and vaniſhed. According to this idea Linneus has obſerved that trees and ſhrubs are roots above ground, for if a tree be inverted, leaves will grow from the root-part and roots from the trunk-part. Phil. Bot. p. 39. Hence it appears that vegetables have two methods of propagating themſelves, the oviparous as by ſeeds, and the viviparous as by their buds and bulbs, and that the individual plants, whether from ſeeds or buds or bulbs, are all annual productions like many kinds of inſects as the ſilk-worm, the parent periſhing in the autumn after having produced an embryon, which lies in a torpid ſtate during the winter, and is matured in the ſucceeding ſummer. Hence Linneus names buds and bulbs the winter-cradles of the plant or hybernacula, and might have given the ſame term to ſeeds. In warm climates few plants produce buds, as the vegetable life can be compleated in one ſummer, and hence the hybernacle is not wanted; in cold climates alſo ſome plants do not produce buds, as philadelphus, frangula, viburnum, ivy, heath, woodnightſhade, rue, geranium.

The bulbs of plants are another kind of winter-cradle, or hybernacle, adhering to the deſcending trunk, and are found in the perennial herbaceous plants which are too tender to bear the cold of the winter. The production of theſe ſubterraneous winter lodges, is not yet perhaps clearly underſtood, they have been diſtributed by Linneus according to their forms into ſcaly, ſolid, coated, and jointed bulbs, which however does not elucidate their manner of production. As the buds of trees may be truly eſteemed individual annual plants, their roots conſtituting the bark of the tree, it follows that theſe roots (viz. of each individual bud) ſpread themſelves over the laſt year's bark, making a new bark over the old one, and thence deſcending cover with a new bark the old roots alſo in the ſame manner. A ſimilar circumſtance I ſuppoſe to happen in ſome herbaceous plants, that is, a new bark is annually produced over the old root, and thus for ſome years at leaſt the old root or caudex increaſes in ſize and puts up new ſtems. As theſe roots increaſe in ſize the central part I ſuppoſe changes like the internal wood of a tree and does not poſſeſs any vegetable life, and therefore gives out no fibres or rootlets, and hence appears bitten off, as in valerian, plantain, and devil's-bit. And this decay of the central part of the root I ſuppoſe has given occaſion to the belief of the root-fibres drawing down the bulb ſo much inſiſted on by Mr. Milne in his Botanical Dictionary, Art. Bulb.

From the obſervations and drawings of various kinds of bulbous roots at different times of their growth, ſent me by a young lady of nice obſervation, it appears probable that all bulbous roots properly ſo called periſh annually in this climate: Bradley, Miller, and the Author of Spectacle de la Nature, obſerve that the tulip annually renews its bulb, for the ſtalk of the old flower is found under the old dry coat but on the outſide of the new bulb. This large new bulb is the flowering bulb, but beſides this there are other ſmall new bulbs produced between the coats of this large one but from the ſame caudex, (or circle from which the root-fibres ſpring;) theſe ſmall bulbs are leaf-bearing bulbs, and renew themſelves annually with increaſing ſize till they bear flowers.

Miſs ——— favoured me with the following curious experiment: She took a ſmall tulip-root out of the earth when the green leaves were ſufficiently high to ſhow the flower, and placed it in a glaſs of water; the leaves and flower ſoon withered and the bulb became wrinkled and ſoft, but put out one ſmall ſide bulb and three bulbs beneath deſcending an inch into the water by long proceſſes from the caudex, the old bulb in ſome weeks intirely decayed; on diſſecting this monſter, the middle deſcending bulb was found by its proceſs to adhere to the caudex and to the old flower-ſtem, and the ſide ones were ſeparated from the flower-ſtem by a few ſhrivelled coats but adhered to the caudex. Whence ſhe concludes that, theſe laſt were off-ſets or leaf-bulbs which ſhould have been ſeen between the coats of the new flower bulb if it had been left to grow in the earth, and that the middle one would have been the new flower-bulb. In ſome years (perhaps in wet ſeaſons) the floriſts are ſaid to loſe many of their tulip-roots by a ſimilar proceſs, the new leaf-bulbs being produced beneath the old ones by an elongation of the caudex without any new flower-bulbs.

By repeated diſſections ſhe obſerves that the leaf-bulbs or off-ſets of tulip, crocus, gladiolus, fritillary, are renewed in the ſame manner as the flowering-bulbs, contrary to the opinion of many writers; this new leaf-bulb is formed on the inſide of the coats from whence the leaves grow, and is more or leſs advanced in ſize as the outer coats and leaves are more or leſs ſhrivelled. In examining tulip, iris, hyacinth, hare-bell, the new bulb was invariably found *between* the flower-ſtem and the baſe of the innermoſt leaf of thoſe roots which had flowered and *incloſed by* the baſe of the innermoſt leaf in thoſe roots which had not flowered, in both caſes adhering to the caudex or fleſhy circle from which the root-fibres ſpring.

Hence it is probable that the bulbs of hyacinths are renewed annually, but that this is performed from the caudex within the old bulb, the outer coat of which does not ſo ſhrivel as in crocus and fritillary, and hence this change is not ſo apparent. But I believe as ſoon as the flower is advanced the new bulbs may be ſeen on diſſection, nor does the annual increaſe of the ſize of the root of cyclamen and of aletris capenſis militate againſt this annual renewal of them, ſince the leaf-bulbs or off-ſets, as deſcribed above, are increaſed in ſize as they are annually renewed. See note on orchis, and on anthoxanthum, in Vol. II. of this work.

# NOTE XV.——SOLAR VOLCANOS.

*From the deep craters of his realms of fire*
*The whirling ſun this ponderous planet hurl'd.*

CANTO II. l. 14.

DR. ALEXANDER WILSON, Profeſſor of Aſtronomy at Glaſgow, publiſhed a paper in the Philoſophical Tranſactions for 1774, demonſtrating that the ſpots in the ſun's diſk are real cavities, excavations through the luminous material, which covers the other parts of the ſun's ſurface. One of theſe cavities he found to be about 4000 miles deep and many times as wide. Some objections were made to this doctrine by M. De la Laude in the Memoirs of the French Academy for the year 1776, which however have been ably anſwered by Profeſſor Wilſon in reply in the Philoſ. Tranſ. for 1783. Keil obſerves, in his Aſtronomical Lectures, p. 44, "We frequently ſee ſpots in the ſun which are larger and broader not only than Europe or Africa, but which even equal, if they do not exceed, the ſurface of the whole terraqueous globe." Now that theſe cavities are made in the ſun's body by a proceſs of nature ſimilar to our earthquakes does not ſeem improbable on ſeveral accounts. 1. Becauſe from this diſcovery of Dr. Wilſon it appears that the internal parts of the ſun are not in a ſtate of inflammation or of ejecting light, like the external part or luminous ocean which covers it; and hence that a greater degree of heat or inflammation and conſequent expanſion or exploſion may occaſionally be produced in its internal or dark nucleus. 2. Becauſe the ſolar ſpots or cavities are frequently increaſed or diminiſhed in ſize. 3. New ones are often produced. 4. And old ones vaniſh. 5. Becauſe there are brighter or more luminous parts of the ſun's diſk, called faculæ by Scheiner and Hevelius, which would ſeem to be volcanos in the ſun, or, as Dr. Wilſon calls them, "eructations of matter more luminous than that which covers the ſun's ſurface." 6. To which may be added that all the planets added together with their ſatellites do not amount to more than one ſix hundred and fiftieth part of the maſs of the ſun according to Sir Iſaac Newton.

Now if it could be ſuppoſed that the planets were originally thrown out of the ſun by larger ſun-quakes than thoſe frequent ones which occaſion theſe ſpots or excavations above-mentioned, what would happen? 1. According to the obſervations and opinion of Mr. Herſchel the ſun itſelf and all its planets are moving forwards round ſome other centre with an unknown velocity, which may be of opake matter correſponding with the very antient and general idea of a chaos. Whence if a ponderous planet, as Saturn, could be ſuppoſed to be projected from the ſun by an exploſion, the motion of the Sun itſelf might be at the ſame time diſturbed in ſuch a manner as to prevent the planet from falling again into it. 2. As the ſun revolves round its own axis its form muſt be that of an oblate ſpheroid like the earth, and therefore a body projected from its ſurface perpendicularly upwards from that ſurface would not riſe perpendicularly from the ſun's centre, unleſs it happened to be projected exactly from either of its poles or from its equator. Whence it may not be neceſſary that a planet if thus projected from the ſun by exploſion ſhould again fall into the ſun. 3. They would part from the ſun's ſurface with the velocity with which that ſurface was moving, and with the velocity acquired by the exploſion, and would therefore move round the ſun in the ſame direction in which the ſun rotates on its axis, and perform eliptic orbits. 4. All the planets would move the ſame way round the ſun, from this firſt motion acquired at leaving its ſurface, but their orbits would be inclined to each other according to the diſtance of the part, where they were thrown out, from the ſun's equator. Hence thoſe which were ejected near the ſun's equator would have orbits but little inclined to each other, as the primary planets; the plain of whoſe orbits are inclined but ſeven degrees and a half from each other. Others which were ejected near the ſun's poles would have much more eccentric orbits, as they would partake ſo much leſs of the ſun's rotatory motion at the time they parted from his ſurface, and would therefore be carried further from the ſun by the velocity they had gained by the exploſion which ejected them, and become comets. 5. They would all obey the ſame laws of motion in their revolutions round the ſun; this has been determined by aſtronomers, who have demonſtrated that they move through equal areas in equal times. 6. As their annual periods would depend on the height they roſe by the exploſion, theſe would differ in them all. 7. As their diurnal revolutions would depend on one ſide of the exploded matter adhering more than the other at the time it was torn off by the exploſion, theſe would alſo differ in the different planets, and not bear any proportion to their annual periods. Now as all theſe circumſtances coincide with the known laws of the planetary ſyſtem, they ſerve to ſtrengthen this conjecture.

This coincidence of ſuch a variety of circumſtances induced M. de Buffon to ſuppoſe that the planets were all ſtruck off from the ſun's ſurface by the impact of a large comet, ſuch as approached ſo near the ſun's diſk, and with ſuch amazing velocity, in the year 1680, and is expected to return in 2255. But Mr. Buffon did not recollect that theſe comets themſelves are only planets with more eccentric orbits, and that therefore it muſt be aſked, what had previouſly ſtruck off theſe comets from the ſun's body? 2. That if all theſe planets were ſtruck off from the ſun at the ſame time, they muſt have been ſo near as to have attracted each other and have formed one maſs: 3. That we ſhall want new cauſes for ſeparating the ſecondary planets from the primary ones, and muſt therefore look out for ſome other agent, as it does not appear how the impulſe of a comet could have made one planet roll round another at the time they both of them were driven off from the ſurface of the ſun.

If it ſhould be aſked, why new planets are not frequently ejected from the ſun? it may be anſwered, that after many large earthquakes many vents are left from the elaſtic vapours to eſcape, and hence, by the preſent appearance of the ſurface of our earth, earthquakes prodigiouſly larger than any recorded in hiſtory have exiſted; the ſame circumſtances may have affected the ſun, on whoſe ſurface there are appearances of volcanos, as deſcribed above. Add to this, that ſome of the comets, and even the georgium ſidus, may, for aught we know to the contrary, have been emitted from the ſun in more modern days, and have been diverted from their courſe, and thus prevented from returning into the ſun, by their approach to ſome of the older planets, which is ſomewhat countenanced by the opinion ſeveral philoſophers have maintained, that the quantity of matter of the ſun has decreaſed. Dr. Halley obſerved, that by comparing the proportion which the periodical time of the moon bore to that of the ſun in former times, with the proportion between them at preſent, that the moon is found to be ſomewhat accelerated in reſpect to the ſun. Pemberton's View of Sir Iſaac Newton, p. 247. And ſo large is the body of this mighty luminary, that all the planets thus thrown out of it would make ſcarcely any perceptible diminution of it, as mentioned above. The cavity mentioned above, as meaſured by Dr. Wilſon, of 4000 miles in depth, not penetrating an hundredth part of the ſun's ſemi-diameter; and yet, as its width was many times greater than its depth, was large enough to contain a greater body than our terreſtrial world.

I do not mean to conceal, that from the laws of gravity unfolded by Sir Iſaac Newton, ſuppoſing the ſun to be a ſphere and to have no progreſſive motion, and not liable itſelf to be diſturbed by the ſuppoſed projection of the planets from it, that ſuch planets muſt return into the ſun. The late Rev. William Ludlam, of Leiceſter, whoſe genius never met with reward equal to its merits, in a letter to me, dated January, 1787, after having ſhewn, as mentioned above, that planets ſo projected from the ſun would return to it, adds, "That a body as "large as the moon ſo projected, would diſturb the motion of the earth "in its orbit, is certain; but the calculation of ſuch diſturbing forces "is difficult. The body in ſome circumſtances might become a ſa-"tellite, and both move round their common centre of gravity, and "that centre be carried in an annual orbit round the ſun."

There are other circumſtances which might have concurred at the time of ſuch ſuppoſed exploſions, which would render this idea not impoſſible. 1. The planets might be thrown out of the ſun at the time the ſun itſelf was riſing from chaos, and be attracted by other ſuns in their vicinity riſing at the ſame time out of chaos, which would prevent them from returning into the ſun. 2. The new planet in its courſe or aſcent from the ſun, might explode and eject a ſatellite, or perhaps more than one, and thus by its courſe being affected might not return into the ſun. 3. If more planets were ejected at the ſame time from the ſun, they might attract and diſturb each others courſe at the time they left the body of the ſun, or very ſoon afterwards, when they would be ſo much nearer each other.

## NOTE XVI.——CALCAREOUS EARTH.

*While Ocean wrap'd it in his azure robe.*

CANTO II. l. 34.

FROM having obſerved that many of the higheſt mountains of the world conſiſt of lime-ſtone replete with ſhells, and that theſe mountains bear the marks of having been lifted up by ſubterraneous fires from the interior parts of the globe; and as lime-ſtone replete with ſhells is found at the bottom of many of our deepeſt mines, ſome philoſophers have concluded that the nucleus of the earth was for many ages covered with water which was peopled with its adapted animals; that the ſhells and bones of theſe animals in a long ſeries of time produced ſolid ſtrata in the ocean ſurrounding the original nucleus.

Theſe ſtrata conſiſt of the accumulated exuviæ of ſhell-fiſh, the animals periſhed age after age but their ſhells remained, and in progreſſion of time produced the amazing quantities of lime-ſtone which almoſt cover the earth. Other marine animals called coralloids raiſed walls and even mountains by the congeries of their calcareous habitations, theſe perpendicular corralline rocks make ſome parts of the Southern Ocean highly dangerous, as appears in the journals of Capt. Cook. From contemplating the immenſe ſtrata of lime-ſtone, both in reſpect to their extent and thickneſs, formed from theſe ſhells of animals, philoſophers have been led to conclude that much of the water of the ſea has been converted into calcareous earth by paſſing through their organs of digeſtion. The formation of calcareous earth ſeems more particularly to be an animal proceſs as the formation of clay belongs to the vegetable economy; thus the ſhells of crabs and other teſtaceous fiſh are annually reproduced from the mucous membrane beneath them; the ſhells of eggs are firſt a mucous membrane, and the calculi of the kidneys and thoſe found in all other parts of our ſyſtem which ſometimes contain calcareous earth, ſeem to originate from inflamed membranes; the bones themſelves conſiſt of calcareous earth united with the phoſphoric or animal acid, which may be ſeparated by diſſolving the aſhes of calcined bones in the nitrous acid; the various ſecretions of animals, as their ſaliva and urine, abound likewiſe with calcareous earth, as appears by the incruſtations about the teeth and the ſediments of urine. It is probable that animal mucus is a previous proceſs towards the formation of calcareous earth; and that all the calcareous earth in the world which is ſeen in lime-ſtones, marbles, ſpars, alabaſters, marls, (which make up the greateſt part of the earth's cruſt, as far as it has yet been penetrated,) have been formed originally by animal and vegetable bodies from the maſs of water, and that by theſe means the ſolid part of the terraqueous globe has perpetually been in an increaſing ſtate and the water perpetually in a decreaſing one.

After the mountains of ſhells and other recrements of aquatic animals were elevated above the water, the upper heaps of them were gradually diſſolved by rains and dews, and oozing through were either perfectly cryſtallized in ſmaller cavities and formed calcareous ſpar, or were imperfectly cryſtallized on the roofs of larger cavities and produced ſtalactites; or mixing with other undiſſolved ſhells beneath them formed marbles, which were more or leſs cryſtallized and more or leſs pure; or laſtly, after being diſſolved, the water was exhaled from them in ſuch a manner that the external parts became ſolid, and forming an arch prevented the internal parts from approaching each other ſo near as to become ſolid, and thus chalk was produced. I have ſpecimens of chalk formed at the root of ſeveral ſtalactites, and in their central parts; and of other ſtalactites which are hollow like quills from a ſimilar cauſe, viz. from the external part of the ſtalactite hardening firſt by its evaporation, and thus either attracting the internal diſſolved particles to the cruſt, or preventing them from approaching each other ſo as to form a ſolid body. Of theſe I ſaw many hanging from the arched roof of a cellar under the high ſtreet in Edinburgh.

If this diſſolved limeſtone met with vitriolic acid it was converted into alabaſter, parting at the ſame time with its fixable air. If it met with the fluor acid it became fluor; if with the ſiliceous acid, flint; and when mixed with clay and ſand, or either of them, acquires the name of marl. And under one or other of theſe forms compoſes a great part of the ſolid globe of the earth.

Another mode in which limeſtone appears is in the form of round granulated particles, but ſlightly cohering together; of this kind a bed extends over Lincoln heath, perhaps twenty miles long by ten wide. The form of this calcareous ſand, its angles having been rubbed off, and the flatneſs of its bed, evinces that that part of the country was ſo formed under water, the particles of ſand having thus been rounded, like all other rounded pebbles. This round form of calcareous ſand and of other larger pebbles is produced under water, partly by their being more or leſs ſoluble in water, and hence the angular parts became diſſolved, firſt by their expoſing a larger ſurface to the action of the menſtruum, and ſecondly, from their attrition againſt each other by the ſtreams or tides, for a great length of time, ſucceſſively as they were collected, and perhaps when ſome of them had not acquired their hardeſt ſtate.

This calcareous ſand has generally been called ketton-ſtone and believed to reſemble the ſpawn of fiſh, it has acquired a form ſo much rounder than ſiliceous ſand from its being of ſo much ſofter a texture and alſo much more ſoluble in water. There are other ſoft calcareous ſtones called tupha which are depoſited from water on moſſes, as at Matlock, from which moſs it is probable the water may receive ſomething which induces it the readier to part with its earth.

In ſome lime-ſtones the living animals ſeem to have been buried as well as their ſhells during ſome great convulſion of nature, theſe ſhells contain a black coaly ſubſtance within them, in others ſome phlogiſton or volatile alcali from the bodies of the dead animals remains mixed with the ſtone, which is then called liver-ſtone as it emits a ſulphureous ſmell on being ſtruck, and there is a ſtratum about ſix inches thick extends a conſiderable way over the iron ore at Wingerworth near Cheſterfield in Derbyſhire, which ſeems evidently to have been formed from the ſhells of freſh-water muſcles.

There is however another ſource of calcareous earth beſides the aquatic one above deſcribed, and that is from the recrements of land animals and vegetables as found in marls, which conſiſt of various mixtures of calcareous earth, ſand, and clay, all of them perhaps principally from vegetable origin.

Dr. Hutton is of opinion that the rocks of marble have been ſoftened by fire into a fluid maſs, which he thinks under immenſe preſſure might be done without the eſcape of their carbonic acid or fixed air. Edinb. Tranſact. Vol. I. If this ingenious idea be allowed it might account for the purity of ſome white marbles, as during their fluid ſtate there might be time for their partial impurities, whether from the bodies of the animals which produced the ſhells or from other extraneous matter, either to ſublime to the uppermoſt part of the ſtratum or to ſubſide to the lowermoſt part of it. As a confirmation of this theory of Dr. Hutton's it may be added that ſome calcareous ſtones are found mixed with lime, and have thence loſt a part of their fixed air or carbonic gas, as the bath-ſtone, and on that account hardens on being expoſed to the air, and mixed with ſulphur produces calcareous liver of ſulphur. Falconer on Bath-water. Vol. I. p. 156. and p. 257. Mr. Monnet found lime in powder in the mountains of Auvergne, and ſuſpected it of volcanic origin. Kirwan's Min. p. 22.

## NOTE XVII.——MORASSES.

*Gnomes! you then taught tranſuding dews to paſs*
*Through time-fallen woods, and root-inwove moraſs.*
CANTO II. l. 113.

WHERE woods have repeatedly grown and periſhed, moraſſes are in proceſs of time produced, and by their long roots fill up the interſtices till the whole becomes for many yards deep a maſs of vegetation. This fact is curiouſly verified by an account given many years ago by the Earl of Cromartie, of which the following is a ſhort abſtract.

In the year 1651 the EARL OF CROMARTIE being then nineteen years of age ſaw a plain in the pariſh of Lockburn covered over with a firm ſtanding wood, which was ſo old that not only the trees had no green leaves upon them but the bark was totally thrown off, which he was there informed by the old countrymen was the univerſal manner in which fir-woods terminated, and that in twenty or thirty years the trees would caſt themſelves up by the roots. About fifteen years after he had occaſion to travel the ſame way and obſerved that there was not a tree nor the appearance of a root of any of them; but in their place the whole plain where the wood ſtood was covered with a flat green moſs or moraſs, and on aſking the country people what was become of the wood he was informed that no one had been at the trouble to carry it away, but that it had all been overturned by the wind, that the trees lay thick over each other, and that the moſs or bog had overgrown the whole timber, which they added was occaſioned by the moiſture which came down from the high hills above it and ſtagnated upon the plain, and that nobody could yet paſs over it, which however his Lordſhip was ſo incautious as to attempt and ſlipt up to the arm-pits. Before the year 1699 that whole piece of ground was become a ſolid moſs wherein the peaſants then dug turf or peat, which however was not yet of the beſt ſort. Philoſ. Tranſ. No. 330. Abridg. Vol. V. p. 272.

Moraſſes in great length of time undergo variety of changes, firſt by elutriation, and afterwards by fermentation, and the conſequent heat. 1. By water perpetually oozing through them the moſt ſoluble parts are firſt waſhed away, as the eſſential ſalts, theſe together with the ſalts from animal recrements are carried down the rivers into the ſea, where all of them ſeem to decompoſe each other except the marine ſalt. Hence the aſhes of peat contain little or no vegetable alcali, and are not uſed in the countries where peat conſtitutes the fuel of the lower people, for the purpoſe of waſhing linen. The ſecond thing which is always ſeen oozing from moraſſes is iron in ſolution, which produces chalybeate ſprings, from whence depoſitions of ochre and variety of iron ores. The third elutriation ſeems to conſiſt of vegetable acid, which by means unknown appears to be converted into all other acids. 1. Into marine and nitrous acids as mentioned above. 2. Into vitriolic acid, which is found in ſome moraſſes ſo plentifully as to preſerve the bodies of animals from putrefaction which have been buried in them, and this acid carried away by rain and dews and meeting with calcareous earth produces gypſum or alabaſter, with clay it produces alum, and deprived of its vital air produces ſulphur. 3. Fluor acid, which being waſhed away and meeting with calcareous earth produces fluor or cubic ſpar. 4. The ſiliceous acid, which ſeems to have been diſſeminated in great quantity either by ſolution in water or by ſolution in air, and appears to have produced the ſand in the ſea uniting with calcareous earth previouſly diſſolved in that element, from which were afterwards formed ſome of the grit-ſtone rocks by means of a ſiliceous or calcareous cement. By its union with the calcareous earth of the moraſs other ſtrata of ſiliceous ſand have been produced; and by the mixture of this with clay and lime aroſe the beds of marl.

In other circumſtances, probably where leſs moiſture has prevailed, moraſſes ſeem to have undergone a fermentation, as other vegetable matter, new hay for inſtance is liable to do from the great quantity of ſugar it contains. From the great heat thus produced in the lower parts of immenſe beds of moraſs, the phlogiſtic part, or oil, or aſphaltum, becomes diſtilled, and riſing into higher ſtrata becomes again condenſed, forming coal-beds of greater or leſs purity according to their greater or leſs quantity of inflammable matter; at the ſame time the clay beds become purer or leſs ſo, as the phlogiſtic part is more or leſs completely exhaled from them. Though coal and clay are frequently produced in this manner, yet I have no doubt, but that they are likewiſe often produced by elutriation; in ſituations on declivities the clay is waſhed away down into the valleys, and the phlogiſtic part or coal left behind; this circumſtance is ſeen in many valleys near the beds of rivers, which are covered recently by a whitiſh and pure clay, called water-clay. See note XIX. XX. and XXIII.

LORD CROMARTIE has furniſhed another curious obſervation on moraſſes in the paper above referred to. In a moſs near the town of Eglin in Murray, though there is no river or water which communicates with the moſs, yet for three or four feet of depth in the moſs there are little ſhell-fiſh reſembling oyſters with living fiſh in them in great quantities, though no ſuch fiſh are found in the adjacent rivers, nor even in the water pits in the moſs, but only in the ſolid ſubſtance of the moſs. This curious fact not only accounts for the ſhells ſometimes found on the ſurface of coals, and in the clay above them; but alſo for a thin ſtratum of ſhells which ſometimes exiſt over iron-ore.

## NOTE XVIII.——IRON.

*Cold waves, immerged, the glowing maſs congeal,*
*And turn to adamant the hiſſing Steel.*

CANTO II. l. 191.

AS iron is formed near the ſurface of the earth, it becomes expoſed to ſtreams of water and of air more than moſt other metallic bodies, and thence becomes combined with oxygene, or vital air, and appears very frequently in its calciform ſtate, as in variety of ochres. Mangeneſe, and zinc, and ſometimes lead, are alſo found near the ſurface of the earth, and on that account become combined with vital air and are exhibited in their calciform ſtate.

The avidity with which iron unites with oxygene, or vital air, in which proceſs much heat is given out from the combining materials, is ſhewn by a curious experiment of Ingenhouz. A fine iron wire twiſted ſpirally is fixed to a cork, on the point of the ſpire is fixed a match made of agaric dipped in ſolution of nitre; the match is then ignited, and the wire with the cork put immediately into a bottle full of vital air, the match firſt burns vividly, and the iron ſoon takes fire and conſumes with brilliant ſparks till it is reduced to ſmall brittle globules, gaining an addition of about one third of its weight by its union with vital air. Annales de Chymie. Traité de Chimie, per Lavoiſier, c. iii.

## STEEL.

It is probably owing to a total deprivation of vital air which it holds with ſo great avidity, that iron on being kept many hours or days in ignited charcoal becomes converted into ſteel, and thence acquires the faculty of being welded when red hot long before it melts, and alſo the power of becoming hard when immerſed in cold water; both which I ſuppoſe depend on the ſame cauſe, that is, on its being a worſe conductor of heat than other metals; and hence the ſurface both acquires heat much ſooner, and loſes it much ſooner, than the internal parts of it, in this circumſtance reſembling glaſs.

When ſteel is made very hot, and ſuddenly immerged in very cold water, and moved about in it, the ſurface of the ſteel becomes cooled firſt, and thus producing a kind of caſe or arch over the internal part, prevents that internal part from contracting quite ſo much as it otherwiſe would do, whence it becomes brittler and harder, like the glaſs-drops called Prince Rupert's drops, which are made by dropping melted glaſs into cold water. This idea is countenanced by the circumſtance that hardened ſteel is ſpecifically lighter than ſteel which is more gradually cooled. (Nicholſon's Chemiſtry, p. 313.) Why the brittleneſs and hardneſs of ſteel or glaſs ſhould keep pace or be companions to each other may be difficult to conceive.

When a ſteel ſpring is forcibly bent till it break, it requires leſs power to bend it through the firſt inch than the ſecond, and leſs through the ſecond than the third; the ſame I ſuppoſe to happen if a wire be diſtended till it break by hanging weights to it; this ſhews that the particles may be forced from each other to a ſmall diſtance by leſs power than is neceſſary to make them recede to a greater diſtance; in this circumſtance perhaps the attraction of coheſion differs from that of gravitation, which exerts its power inverſely as the ſquares of the diſtance. Hence it appears that if the innermoſt particles of a ſteel bar, by cooling the external ſurface firſt, are kept from approaching each other ſo nearly as they otherwiſe would do, that they become in the ſituation of the particles on the convex ſide of a bent ſpring, and can not be forced further from each other except by a greater power than would have been neceſſary to have made them recede thus far. And ſecondly, that if they be forced a little further from each other they ſeparate; this may be exemplified by laying two magnetic needles parallel to each other, the contrary poles together, then drawing them longitudinally from each other, they will ſlide with ſmall force till they begin to ſeparate, and will then require a ſtronger force to really ſeparate them. Hence it appears, that hardneſs and brittleneſs depend on the ſame circumſtance, that the particles are removed to a greater diſtance from each other and thus reſiſt any power more forcibly which is applied to diſplace them further, this conſtitutes hardneſs. And ſecondly, if they are diſplaced by ſuch applied force they immediately ſeparate, and this conſtitutes brittleneſs.

Steel may be thus rendered too brittle for many purpoſes, on which account artiſts have means of ſoftening it again, by expoſing it to certain degrees of heat, for the conſtruction of different kinds of tools, which is called tempering it. Some artiſts plunge large tools in very cold water as ſoon as they are compleatly ignited, and moving it about, take it out as ſoon as it ceaſes to be luminous beneath the water; it is then rubbed quickly with a file or on ſand to clean the ſurface, the heat which the metal ſtill retains ſoon begins to produce a ſucceſſion of colours; if a hard temper be required, the piece is dipped again and ſtirred about in cold water as ſoon as the yellow tinge appears, if it be cooled when the purple tinge appears it becomes fit for gravers' tools uſed in working upon metals; if cooled while blue it is proper for ſprings. Nicholſon's Chemiſtry, p. 313. Keir's Chemical Dictionary.

## MODERN PRODUCTION OF IRON.

The recent production of iron is evinced from the chalybeate waters which flow from moraſſes which lie upon gravel-beds, and which muſt therefore have produced iron after thoſe gravel-beds were raiſed out of the ſea. On the ſouth ſide of the road between Cheadle and Okeymoor in Staffordſhire, yellow ſtains of iron are ſeen to penetrate the gravel from a thin moraſs on its ſurface. There is a fiſſure eight or ten feet wide, in a gravel-bed on the eaſtern ſide of the hollow road aſcending the hill about a mile from Trentham in Staffordſhire, leading toward Drayton in Shropſhire, which fiſſure is filled up with nodules of iron-ore. A bank of ſods is now raiſed againſt this fiſſure to prevent the looſe iron nodules from falling into the turnpike road, and thus this natural curioſity is at preſent concealed from travellers. A ſimilar fiſſure in a bed of marl, and filled up with iron nodules and with ſome large pieces of flint, is ſeen on the eaſtern ſide of the hollow road aſcending the hill from the turnpike houſe about a mile from Derby in the road towards Burton. And another ſuch fiſſure filled with iron nodes, appears about half a mile from Newton-Solney in Derbyſhire, in the road to Burton, near the ſummit of the hill. Theſe collections of iron and of flint muſt have been produced poſterior to the elevation of all thoſe hills, and were thence evidently of vegetable or animal origin. To which ſhould be added, that iron is found in general in beds either near the ſurface of the earth, or ſtratified with clay coals or argillaceous grit, which are themſelves productions of the modern world, that is, from the recrements of vegetables and air-breathing animals.

Not only iron but manganeſe, calamy, and even copper and lead appear in ſome inſtances to have been of recent production. Iron and mangameſe are detected in all vegetable productions, and it is probable other metallic bodies might be found to exiſt in vegetable or animal matters, if we had teſts to detect them in very minute quantities. Manganeſe and calamy are found in beds like iron near the ſurface of the earth, and in a calciform ſtate, which countenances their modern production. The recent production of calamy, one of the ores of zinc, appears from its frequently incruſting calcareous ſpar in its deſcent from the ſurface of the earth into the uppermoſt fiſſures of the limeſtone mountains of Derbyſhire. That the calamy has been carried by its ſolution or diffuſion in water into theſe cavities, and not by its aſcent from below in form of ſteam, is evinced from its not only forming a cruſt over the dogtooth ſpar, but by its afterwards diſſolving or deſtroying the ſparry cryſtal. I have ſpecimens of calamy in the form of dogtooth ſpar, two inches high, which are hollow, and ſtand half an inch above the diminiſhed ſparry cryſtal on which they were formed, like a ſheath a great deal too big for it; this ſeems to ſhew, that this proceſs was carried on in water, otherwiſe after the calamy had incruſted its ſpar, and diſſolved its ſurface, ſo as to form a hollow cavern over it, it could not act further upon it except by the interpoſition of ſome medium. As theſe ſpars and calamy are formed in the fiſſures of mountains they muſt both have been formed after the elevation of thoſe mountains.

In reſpect to the recent production of copper, it was before obſerved in note on Canto II. l. 394, that the ſummit of the grit-ſtone mountain at Hawkſtone in Shropſhire, is tinged with copper, which from the appearance of the blue ſtains ſeems to have deſcended to the parts of the rock beneath. I have a calciform ore of copper conſiſting of the hollow cruſts of cubic cells, which has evidently been formed on cryſtals of fluor, which it has eroded in the ſame manner as the calamy erodes the calcareous cryſtals, from whence may be deduced in the ſame manner, the aqueous ſolution or diffuſion, as well as the recent production of this calciform ore of copper.

Lead in ſmall quantities is ſometimes found in the fiſſures of coal-beds, which fiſſures are previouſly covered with ſpar; and ſometimes in nodules of iron-ore. Of the former I have a ſpecimen from near Caulk in Derbyſhire, and of the latter from Colebrook Dale in Shropſhire. Though all theſe facts ſhew that ſome metallic bodies are formed from vegetable or animal recrements, as iron, and perhaps manganeſe and calamy, all which are found near the ſurface of the earth; yet as the other metals are found only in fiſſures of rocks, which penetrate to unknown depths, they may be wholly or in part produced by aſcending ſteams from ſubterraneous fires, as mentioned in note on Canto II. l. 394.

## SEPTARIA OF IRON-STONE.

Over ſome lime works at Walſall in Staffordſhire, I obſerved ſome years ago a ſtratum of iron earth about ſix inches thick, full of very large cavities; theſe cavities were evidently produced when the material paſſed from a ſemifluid ſtate into a ſolid one; as the frit of the potters, or a mixture of clay and water is liable to crack in drying; which is owing to the further contraction of the internal part, after the cruſt is become hard. Theſe hollows are liable to receive extraneous matter, as I believe gypſum, and ſometimes ſpar, and even lead; a curious ſpecimen of the laſt was preſented to me by Mr. Darby of Colebrook Dale, which contains in its cavity ſome ounces of lead-ore. But there are other ſeptaria of iron-ſtone which ſeem to have had a very different origin, their cavities having been formed in cooling or congealing from an ignited ſtate, as is ingeniouſly deduced by Dr. Hutton from their internal ſtructure. Edinb. Tranſact. Vol. I. p. 246. The volcanic origin of theſe curious ſeptaria appears to me to be further evinced from their form and the places where they are found. They conſiſt of oblate ſpheroids, and are found in many parts of the earth totally detached from the beds in which they lie, as at Eaſt Lothian in Scotland. Two of theſe, which now lie before me, were found with many others immerſed in argillaceous ſhale or ſhiver, ſurrounded by broken limeſtone mountains at Bradbourn near Aſhbourn in Derbyſhire, and were preſented to me by Mr. Buxton, a gentleman of that town. One of theſe is about fifteen inches in its equatorial diameter, and about ſix inches in its polar one, and contains beautiful ſtarlike ſeptaria incruſted and in part filled with calcareous ſpar. The other is about eight inches in its equatorial diameter, and about four inches in its polar diameter, and is quite ſolid, but ſhews on its internal ſurface marks of different colours, as if a beginning ſeparation had taken place. Now as theſe ſeptaria contain fifty per cent. of iron, according to Dr. Hutton, they would ſoften or melt into a ſemifluid globule by ſubterraneous fire by leſs heat than the limeſtone in their vicinity; and if they were ejected through a hole or fiſſure would gain a circular motion along with their progreſſive one by their greater friction or adheſion to one ſide of the hole. This whirling motion would produce the oblate ſpheroidical form which they poſſeſs, and which as far as I know can not in any other way be accounted for. They would then harden in the air as they roſe into the colder parts of the atmoſphere; and as they deſcended into ſo ſoft a material as ſhale or ſhiver, their forms would not be injured in their fall; and their preſence in materials ſo different from themſelves becomes accounted for.

About the tropics of the large ſeptarium above mentioned, are circular eminent lines, ſuch as might have been left if it had been coarſely turned in a lathe. Theſe lines ſeem to conſiſt of a fluid matter, which ſeems to have exſuded in circular zones, as their edges appear blunted or retracted; and the ſeptarium ſeems to have ſplit eaſier in ſuch ſections parallel to its equator. Now as the cruſt would firſt begin to cool and harden after its ejection in a ſemifluid ſtate, and the equatorial diameter would become gradually enlarged as it roſe in the air; the internal parts being ſofter would ſlide beneath the polar cruſt, which might crack and permit part of the ſemifluid to exſude, and it is probable the adheſion would thus become leſs in ſections parallel to the equator. Which further confirms this idea of the production of theſe curious ſeptaria. A new-caſt cannon ball red-hot with its cruſt only ſolid, if it were ſhot into the air would probably burſt in its paſſage; as it would conſiſt of a more fluid material than theſe ſeptaria; and thus by diſcharging a ſhower of liquid iron would produce more dreadful combuſtion, if uſed in war, than could be effected by a ball, which had been cooled and was heated again: ſince in the latter caſe the ball could not have its internal parts made hotter than the cruſt of it, without firſt loſing its form.

# NOTE XIX.——FLINT.

*Tranſmute to glittering flints her chalky lands,*
*Or ſink on Ocean's bed in countleſs ſands.*

CANTO II. l. 217.

## 1. SILICEOUS ROCKS.

THE great maſſes of ſiliceous ſand which lie in rocks upon the beds of limeſtone, or which are ſtratified with clay, coal, and iron-ore, are evidently produced in the decompoſition of vegetable or animal matters as explained in the note on moraſſes. Hence the impreſſion of vegetable roots and even whole trees are often found in ſand-ſtone, as well as in coals and iron-ore. In theſe ſand-rocks both the ſiliceous acid and the calcareous baſe ſeem to be produced from the materials of the moraſs; for though the preſence of a ſiliceous acid and of a calcareous baſe have not yet been ſeparately exhibited from flints, yet from the analogy of flint to fluor, and gypſum, and marble, and from the converſion of the latter into flint, there can be little doubt of their exiſtence.

Theſe ſiliceous ſand-rocks are either held together by a ſiliceous cement, or have a greater or leſs portion of clay in them, which in ſome acts as a cement to the ſiliceous cryſtals, but in others is in ſuch great abundance that in burning them they become an imperfect porcelain and are then uſed to repair the roads, as at Cheſterfield in Derbyſhire; theſe are called argillaceous grit by Mr. Kirwan. In other places a calcareous matter cements the cryſtals together; and in other places the ſiliceous cryſtals lie in looſe ſtrata under the marl in the form of white ſand; as at Normington about a mile from Derby.

The loweſt beds of ſiliceous ſand-ſtone produced from moraſſes ſeem to obtain their acid from the moraſs, and their calcareous baſe from the limeſtone on which it reſts. Theſe beds poſſeſs a ſiliceous cement, and from their greater purity and hardneſs are uſed for coarſe grinding-ſtones and ſcythe ſtones, and are ſituated on the edges of lime-ſtone countries, having loſt the other ſtrata of coals, or clay, or iron, which were originally produced above them. Such are the ſand-rocks incumbent on lime-ſtone near Matlock in Derbyſhire. As theſe ſiliceous ſand-rocks contain no marine productions ſcattered amongſt them, they appear to have been elevated, torn to pieces, and many fragments of them ſcattered over the adjacent country by exploſions, from fires within the moraſs from which they have been formed; and which diſſipated every thing inflammable above and beneath them, except ſome ſtains of iron, with which they are in ſome places ſpotted. If theſe ſand-rocks had been accumulated beneath the ſea, and elevated along with the beds of limeſtone on which they reſt, ſome veſtiges of marine ſhells either in their ſiliceous or calcareous ſtate muſt have been diſcerned amongſt them.

## 2. SILICEOUS TREES.

In many of theſe ſand-rocks are found the impreſſions of vegetable roots, which ſeem to have been the moſt unchangeable parts of the plant, as ſhells and ſhark's teeth are found in chalk beds from their being the moſt unchangeable parts of the animal. In other inſtances the wood itſelf is penetrated, and whole trees converted into flint; ſpecimens of which I have by me, from near Coventry, and from a gravel-pit in Shropſhire near Child's Archal in the road to Drayton. Other poliſhed ſpecimens of vegetable flints abound in the cabinets of the curious, which evidently ſhew the concentric circles of woody fibres, and their interſtices filled with whiter ſiliceous matter, with the branching off of the knots when cut horizontally, and the parallel lines of wood when cut longitudinally, with uncommon beauty and variety. Of theſe I poſſeſs ſome beautiful ſpecimens, which were preſented to me by the Earl of Uxbridge.

The colours of theſe ſiliceous vegetables are generally brown, from the iron, I ſuppoſe, or manganeſe, which induced them to cryſtallize or to fuſe more eaſily. Some of the cracks of the wood in drying are filled with white flint or calcedony, and others of them remain hollow, lined with innumerable ſmall cryſtals tinged with iron, which I ſuppoſe had a ſhare in converting their calcareous matter into ſiliceous cryſtals, becauſe the cryſtals called Peak-diamonds are always found bedded in an ochreous earth; and thoſe called Briſtol-ſtones are ſituated on limeſtone coloured with iron. Mr. F. French preſented me with a congeries of ſiliceous cryſtals, which he gathered on the crater (as he ſuppoſes) of an extinguiſhed volcano at Cromach Water in Cumberland. The cryſtals are about an inch high in the ſhape of dogtooth or calcareous ſpar, covered with a dark ferruginous matter. The bed on which they reſt is about an inch in thickneſs, and is ſtained with iron on its underſurface. This curious foſſil ſhews the tranſmutation of calcareous earth into ſiliceous, as much as the ſiliceous ſhells which abound in the cabinets of the curious. There may ſometime be diſcovered in this age of ſcience, a method of thus impregnating wood with liquid flint, which would produce pillars for the ſupport, and tiles for the covering of houſes, which would be uninflammable and endure as long as the earth beneath them.

That ſome ſiliceous productions have been in a fluid ſtate without much heat at the time of their formation, appears from the vegetable flints above deſcribed not having quite loſt their organized appearance; from ſhells, and coralloids, and entrochi being converted into flint without loſing their form; from the baſon of calcedony round Gieſar in Iceland, and from the experiment of Mr. Bergman, who obtained thirteen regular formed cryſtals by ſuffering the powder of quartz to remain in a veſſel with fluor acid for two years; theſe cryſtals were about the ſize of ſmall peas, and were not ſo hard as quartz. Opuſc. de Terrâ Siliceâ, p. 33. Mr. Achard procured both calcareous and ſiliceous cryſtals, one from calcareous earth, and the other from the earth of alum, both diſſolved in water impregnated with fixed air; the water filtrating very ſlowly through a porous bottom of baked clay. See Journal de Phyſique, for January, 1778.

## 3. AGATES, ONYXES, SCOTS-PEBBLES.

In ſmall cavities of theſe ſand-rocks, I am informed, the beautiful ſiliceous nodules are found which are called Scot's-pebbles; and which on being cut in different directions take the names of agates, onyxes, ſardonyxes, &c. according to the colours of the lines or ſtrata which they exhibit. Some of the nodules are hollow and filled with cryſtals, others have a nucleus of leſs compact ſiliceous matter which is generally white, ſurrounded with many concentric ſtrata coloured with iron, and other alternate ſtrata of white agate or calcedony, ſometimes to the number of thirty.

I think theſe nodules bear evident marks of their having been in perfect fuſion by either heat alone, or by water and heat, under great preſſure, according to the ingenious theory of Dr. Hutton; but I do not imagine, that they were injected into cavities from materials from without, but that ſome vegetables or part of vegetables containing more iron or manganeſe than others, facilitated the compleat fuſion, thus deſtroying the veſtiges of vegetable organization, which were conſpicuous in the ſiliceous trees above mentioned. Some of theſe nodules being hollow and lined with cryſtals, and others containing a nucleus of white ſiliceous matter of a looſer texture, ſhew they were compoſed of the materials then exiſting in the cavity; which conſiſting before of looſe ſand, muſt take up leſs ſpace when fuſed into a ſolid maſs.

Theſe ſiliceous nodules reſemble the nodules of iron-ſtone mentioned in note on Canto II. l. 179, in reſpect to their poſſeſſing a great number of concentric ſpheres coloured generally with iron, but they differ in this circumſtance, that the concentric ſpheres generally obey the form of the external cruſt, and in their not poſſeſſing a chalybeate nucleus. The ſtalactites formed on the roofs of caverns are often coloured in concentric ſtrata, by their coats being ſpread over each other at different times; and ſome of them, as the cupreous ones, poſſeſs great beauty from this formation; but as theſe are neceſſarily more or leſs of a cylindrical or conic form, the nodules of globular flints above deſcribed cannot have been conſtructed in this manner. To what law of nature then is to be referred the production of ſuch numerous concentric ſpheres? I ſuſpect to the law of congelation.

When ſalt and water are expoſed to ſevere froſty air, the ſalt is ſaid to be precipitated as the water freezes; that is, as the heat in which it was diſſolved, is withdrawn; where the experiment is tried in a bowl or baſon, this may be true, as the ſurface freezes firſt, and the ſalt is found at the bottom. But in a fluid expoſed in a thin phial, I found by experiment, that the extraneous matter previouſly diſſolved by the heat in the mixture was not ſimply ſet at liberty to ſubſide, but was detruded or puſhed backward as the ice was produced. The experiment was this: about two ounces of a ſolution of blue vitriol were accidentally frozen in a thin phial, the glaſs was cracked and fallen to pieces, the ice was diſſolved, and I found a pillar of blue vitriol ſtanding erect on the bottom of the broken bottle. Nor is this power of congelation more extraordinary, than that by its powerful and ſudden expanſion it ſhould burſt iron ſhells and coehorns, or throw out the plugs with which the water was ſecured in them above one hundred and thirty yards, according to the experiments at Quebec by Major Williams. Edinb. Tranſact. Vol. II. p. 23.

In ſome ſiliceous nodules which now lie before me, the external cruſt for about the tenth of an inch conſiſts of white agate, in others it is much thinner, and in ſome much thicker; correſponding with this cruſt there are from twenty to thirty ſuperincumbent ſtrata, of alternately darker and lighter colour; whence it appears, that the external cruſt as it cooled or froze, propelled from it the iron or mangane ſe which was diſſolved in it; this receded till it had formed an arch or vault ſtrong enough to reſiſt its further protruſion; then the next inner ſphere or ſtratum as it cooled or froze, propelled forwards its colouring matter in the ſame manner, till another arch or ſphere produced ſufficient reſiſtance to this frigoreſcent expulſion. Some of them have detruded their colouring matter quite to the centre, the rings continuing to become darker as they are near it; in others the chalybeate arch ſeems to have ſtopped half an inch from the centre, and become thicker by having attracted to itſelf the irony matter from the white nucleus, owing probably to its cooling leſs precipitately in the central parts than at the ſurface of the pebble.

A ſimilar detruſion of a marly matter in circular arches or vaults obtains in the ſalt mines in Cheſhire; from whence Dr. Hutton very ingeniouſly concludes, that the ſalt muſt have been liquified by heat; which would ſeem to be much confirmed by the above theory. Edinb. Tranſact. Vol. I. p. 244.

I cannot conclude this account of Scots-pebbles without obſerving that ſome of them on being ſawed longitudinally aſunder, ſeem ſtill to poſſeſs ſome veſtiges of the cylindrical organization of vegetables; others poſſeſs a nucleus of white agate much reſembling ſome bulbous roots with their concentric coats, or the knots in elm-roots or crab-trees; ſome of theſe I ſuppoſe were formed in the manner above explained, during the congelation of maſſes of melted flint and iron; others may have been formed from a vegetable nucleus, and retain ſome veſtiges of the organization of the plant.

## 4. SAND OF THE SEA.

The great abundance of ſiliceous ſand at the bottom of the ocean may in part be waſhed down from the ſiliceous rocks above deſcribed, but in general I ſuppoſe it derives its acid only from the vegetable and animal matter of moraſſes, which is carried down by floods or by the atmoſphere, and becomes united in the ſea with its calcareous baſe from ſhells and coralloids, and thus aſſumes its cryſtalline form at the bottom of the ocean, and is there intermixed with gravel or other matters waſhed from the mountains in its vicinity.

## 5. CHERT, OR PETROSILEX.

The rocks of marble are often alternately intermixed with ſtrata of chert, or coarſe flint, and this in beds from one to three feet thick, as at Ilam and Matlock, or of leſs than the tenth of an inch in thickneſs, as a mile or two from Bakewell in the road to Buxton. It is difficult to conceive in what manner ten or twenty ſtrata of either limeſtone or flint, of different ſhades of white and black, could be laid quite regularly over each other from ſediments or precipitations from the ſea; it appears to me much eaſier to comprehend, by ſuppoſing with Dr. Hutton, that both the ſolid rocks of marble and the flint had been fuſed by great heat, (or by heat and water,) under immenſe preſſure; by its cooling or congealing the colouring matter might be detruded, and form parallel or curvilinean ſtrata, as above explained.

The colouring matter both of limeſtone and flint was probably owing to the fleſh of peculiar animals, as well as the ſiliceous acid, which converted ſome of the limeſtone into flint; or to ſome ſtrata of ſhell-fiſh having been overwhelmed when alive with new materials, while others dying in their natural ſituations would loſe their fleſhy parts, either by its putrid ſolution in the water or by its being eaten by other ſea-inſects. I have ſome calcareous foſſil ſhells which contain a black coaly matter in them, which was evidently the body of the animal, and others of the ſame kind filled with ſpar inſtead of it. The Labradore ſtone has I ſuppoſe its colours from the nacre or mother-pearl ſhells, from which it was probably produced. And there is a ſtratum of calcareous matter about ſix or eight inches thick at Wingerworth in Derbyſhire over the iron-beds, which is replete with ſhells of freſh-water muſcles, and evidently obtains its dark colour from them, as mentioned in note XVI. Many nodules of flint reſemble in colour as well as in form the ſhell of the echinus or ſea-urchin; others reſemble ſome coralloids both in form and colour; and M. Arduini found in the Monte de Pancraſio, red flints branching like corals, from whence they ſeem to have obtained both their form and their colour. Ferber's Travels in Italy, p. 42.

## 6. NODULES OF FLINT IN CHALK BEDS.

As the nodules of flint found in clalk-beds poſſeſs no marks of having been rounded by attrition or ſolution, I conclude that they have gained their form as well as their dark colour from the fleſh of the ſhell-fiſh from which they had their origin; but which have been ſo compleatly fuſed by heat, or heat and water, as to obliterate all veſtiges of the ſhell, in the ſame manner as the nodules of agate and onyx were produced from parts of vegetables. but which had been ſo completely fuſed as to obliterate all marks of their organization, or as many iron-nodules have obtained their form and origin from peculiar vegetables.

Some nodules in chalk-beds conſiſt of ſhells of echini filled up with chalk, the animal having been diſſolved away by putreſcence in water, or eaten by other ſea-inſects; other ſhells of echini, in which I ſuppoſe the animal's body remained, are converted into flint but ſtill retain the form of the ſhell. Others, I ſuppoſe as above, being more completely fuſed, have become flint coloured by the animal fleſh, but without the exact form either of the fleſh or ſhell of the animal. Many of theſe are hollow within and lined with cryſtals, like the Scot's-pebbles above deſcribed; but as the colouring matter of animal bodies differs but little from each other compared with thoſe of vegetables, theſe flints vary leſs in their colours than thoſe above-mentioned. At the ſame time as they cooled in concentric ſpheres like the Scot's-pebbles, they often poſſeſs faint rings of colours, and always break in conchoide forms like them.

This idea of the production of nodules of flint in chalk-beds is countenanced from the iron which generally appears as theſe flints become decompoſed by the air; which by uniting with the iron in their compoſition reduces it from a vitreſcent ſtate to that of calx, and thus renders it viſible. And ſecondly, by there being no appearance in chalk-beds of a ſtring or pipe of ſiliceous matter connecting one nodule with another, which muſt have happened if the ſiliceous matter, or its acid, had been injected from without, according to the idea of Dr. Hutton. And thirdly, becauſe many of them have very large cavities at their centres, which ſhould not have happened had they been formed by the injection of a material from without.

When ſhells or chalk are thus converted from calcareous to ſiliceous matter by the fleſh of the animal, the new flint being heavier than the ſhell or chalk occupies leſs ſpace than the materials it was produced from; this is the cauſe of frequent cavities within them, where the whole maſs has not been completely fuſed and preſſed together. In Derbyſhire there are maſſes of coralloid and other ſhells which have become ſiliceous, and are thus left with large vacuities ſometimes within and ſometimes on the outſide of the remaining form of the ſhell, like the French millſtones, and I ſuppoſe might ſerve the ſame purpoſe; the gravel of the Derwent is full of ſpecimens of this kind.

Since writing the above I have received a very ingenious account of chalk-beds from Dr. Menish of Chelmsford. He diſtinguiſhes chalk-beds into three kinds; ſuch as have been raiſed from the ſea with little diſturbance of their ſtrata, as the cliffs of Dover and Margate, which he terms *intire* chalk. Another ſtate of chalk is where it has ſuffered much derangement, as the banks of the Thames at Graveſend and Dartford. And a third ſtate where fragments of chalk have been rounded by water, which he terms *alluvial* chalk. In the firſt of theſe ſituations of chalk he obſerves, that the flint lies in ſtrata horizontally, generally in diſtinct nodules, but that he has obſerved two inſtances of ſolid plates or ſtrata of flint, from an inch to two inches in thickneſs, interpoſed between the chalk-beds; one of theſe is in a chalk-bank by the road ſide at Berkhamſtead, the other in a bank on the road from Chatham leading to Canterbury. Dr. Meniſh has further obſerved, that many of the echini are cruſhed in their form, and yet filled with flint, which has taken the form of the cruſhed ſhell, and that though many flint nodules are hollow, yet that in ſome echini the ſiliceum ſeems to have enlarged, as it paſſed from a fluid to a ſolid ſtate, as it ſwells out in a protuberance at the mouth and anus of the ſhell, and that though theſe ſhells are ſo filled with flint yet that in many places the ſhell itſelf remains calcareous. Theſe ſtrata of nodules and plates of flint ſeem to countenance their origin from the fleſh of a ſtratum of animals which periſhed by ſome natural violence, and were buried in their ſhells.

## 7. ANGLES OF SILICEOUS SAND.

In many rocks of ſiliceous ſand the particles retain their angular form, and in ſome beds of looſe ſand, of which there is one of conſiderable purity a few yards beneath the marl at Normington about a mile ſouth of Derby. Other ſiliceous ſand have had their angles rounded off, like the pebbles in gravel-beds. Theſe ſeem to owe their globular form to two cauſes; one to their attrition againſt each other, when they may for centuries have lain at the bottom of the ſea, or of rivers; where they may have been progreſſively accumulated, and thus progreſſively at the ſame time rubbed upon each other by the daſhing of the water, and where they would be more eaſily rolled over each other by their gravity being ſo much leſs than in air. This is evidently now going on in the river Derwent, for though there are no limeſtone rocks for ten or fifteen miles above Derby, yet a great part of the river-gravel at Derby conſiſts of limeſtone nodules, whoſe angles are quite worn off in their deſcent down the ſtream.

There is however another cauſe which muſt have contributed to round the angles both of calcareous and ſiliceous fragments; and that is, their ſolubility in water; calcareous earth is perpetually found ſuſpended in the waters which paſs over it; and the earth of flints was obſerved by Bergman to be contained in water in the proportion of one grain to a gallon. Kirwan's Mineralogy, p. 107. In boiling water, however, it is ſoluble in much greater proportion, as appears from the ſiliceous earth ſublimed in the diſtillation of fluor acid in glaſs veſſels; and from the baſons of calcedony which ſurrounded the jets of hot water near mount Hecla in Iceland. Troil on Iceland. It is probable moſt ſiliceous ſands or pebbles have at ſome ages of the world been long expoſed to aqueous ſteams raiſed by ſubterranean fires. And if fragments of ſtone were long immerſed in a fluid menſtrum, their angular parts would be firſt diſſolved, on account of their greater ſurface.

Many beds of ſiliceous gravel are cemented together by a ſiliceous cement, and are called breccia; as the plumb-pudding ſtones of Hartfordſhire, and the walls of a ſubterraneous temple excavated by Mr. Curzon, at Hagley near Rugely in Staffordſhire; theſe may have been expoſed to great heat as they were immerſed in water; which water under great preſſure of ſuperincumbent materials may have been rendered red-hot, as in Papin's digeſter; and have thus poſſeſſed powers of ſolution with which we are unacquainted.

## 8. BASALTES AND GRANITES.

Another ſource of ſiliceous ſtones is from the granite, or baſaltes, or porphyries, which are of different hardneſſes according to the materials of their compoſition, or to the fire they have undergone; ſuch are the ſtones of Arthur's-hill near Edinburgh, of the Giant's Cauſway in Ireland, and of Charnwood Foreſt in Leiceſterſhire; the uppermoſt ſtratum of which laſt ſeems to have been cracked either by its elevation, or by its haſtily cooling after ignition by the contact of dews or ſnows, and thus breaks into angular fragments, ſuch as the ſtreets of London are paved with; or have had their angles rounded by attrition or by partial ſolution; and have thus formed the common paving ſtones or bowlers; as well as the gravel, which is often rolled into ſtrata amid the ſiliceous ſand-beds, which are either formed or collected in the ſea.

In what manner ſuch a maſs of cryſtallized matter as the Giant's Cauſway and ſimilar columns of baſaltes, could have been raiſed without other volcanic appearances, may be a matter not eaſy to comprehend; but there is another power in nature beſides that of expanſile vapour which may have raiſed ſome materials which have previouſly been in igneous or aqueous ſolution; and that is the act of congelation. When the water in the experiments above related of Major Williams had by congelation thrown out the plugs from the bomb-ſhells, a column of ice roſe from the hole of the bomb ſix or eight inches high. Other bodies I ſuſpect increaſe in bulk which cryſtallize in cooling, as iron and type-metal. I remember pouring eight or ten pounds of melted brimſtone into a pot to cool, and was ſurprized to ſee after a little time a part of the fluid beneath break a hole in the congealed cruſt above it, and gradually riſe into a promontory ſeveral inches high; the baſaltes has many marks of fuſion and of cryſtallization, and may thence, as well as many other kinds of rocks, as of ſpar, marble, petroſilex, jaſper, &c. have been raiſed by the power of congelation, a power whoſe quantity has not yet been aſcertained, and perhaps greater and more univerſal than that of vapours expanded by heat. Theſe baſaltic columns riſe ſometimes out of mountains of granite itſelf, as mentioned by Dr. Beddoes, (Phil. Tranſ. Vol. LXXX.) and as they ſeem to conſiſt of ſimilar materials more completely fuſed, there is ſtill greater reaſon to believe them to have been elevated in the cooling or cryſtallization of the maſs. See note XXIV.

# NOTE XX.—CLAY.

*Whence ductile Clays in wide expanſion ſpread,*
*Soft as the Cygnet's down, their ſnow-white bed.*
CANTO II. l. 276.

THE philoſophers, who have attended to the formation of the earth, have acknowledged two great agents in producing the various changes which the terraqueous globe has undergone, and theſe are water and fire. Some of them have perhaps aſcribed too much to one of theſe great agents of nature, and ſome to the other. They have generally agreed that the ſtratification of materials could only be produced from ſediments or precipitations, which were previouſly mixed or diſſolved in the ſea; and that whatever effects were produced by fire were performed afterwards.

There is however great difficulty in accounting for the univerſal ſtratification of the ſolid globe of the earth in this manner, ſince many of the materials, which appear in ſtrata, could not have been ſuſpended in water; as the nodules of flint in chalk-beds, the extenſive beds of ſhells, and laſtly the ſtrata of coal, clay, ſand, and iron-ore, which in moſt coal-countries lie from five to ſeven times alternately ſtratified over each other, and none of them are ſoluble in water. Add to this if a ſolution of them or a mixture of them in water could be ſuppoſed, the cauſe of that ſolution muſt ceaſe before a precipitation could commence.

1. The great maſſes of lava, under the various names of granite, porphyry, toadſtone, moor-ſtone, rag, and ſlate, which conſtitute the old world, may have acquired the ſtratification, which ſome of them appear to poſſeſs, by their having been formed by ſucceſſive eruptions of a fluid maſs, which at different periods of antient time aroſe from volcanic ſhafts and covered each other, the ſurface of the interior maſs of lava would cool and become ſolid before the ſuperincumbent ſtratum was poured over it; to the ſame cauſe may be aſcribed their different compoſitions and textures, which are ſcarcely the ſame in any two parts of the world.

2. The ſtratifications of the great maſſes of limeſtone, which were produced from ſea-ſhells, ſeem to have been formed by the different times at which the innumerable ſhells were produced and depoſited. A colony of echini, or madrepores, or cornua ammonis, lived and periſhed in one period of time; in another a new colony of either ſimilar or different ſhells lived and died over the former ones, producing a ſtratum of more recent ſhell over a ſtratum of others which had began to petrify or to be-

come marble; and thus from unknown depths to what are now the ſummits of mountains the limeſtone is diſpoſed in ſtrata of varying ſolidity and colour. Theſe have afterwards undergone variety of changes by their ſolution and depoſition from the water in which they were immerſed, or from having been expoſed to great heat under great preſſure, according to the ingenious theory of Dr. Hutton. Edinb. Tranſact. Vol. I. See Note XVI.

3. In moſt of the coal-countries of this iſland there are from five to ſeven beds of coal ſtratified with an equal number of beds, though of much greater thickneſs, of clay and ſandſtone, and occaſionally of iron-ores. In what manner to account for the ſtratification of theſe materials ſeems to be a problem of greater difficulty. Philoſophers have generally ſuppoſed that they have been arranged by the currents of the ſea; but conſidering their inſolubility in water, and their almoſt ſimilar ſpecific gravity, an accumulation of them in ſuch diſtinct beds from this cauſe is altogether inconceivable, though ſome coal-countries bear marks of having been at ſome time immerſed beneath the waves and raiſed again by ſubterranean fires.

The higher and lower parts of moraſſes were neceſſarily produced at different periods of time, ſee Note XVII. and would thus originally be formed in ſtrata of different ages. For when an old wood periſhed, and produced a moraſs, many centuries would elapſe before another wood could grow and periſh again upon the ſame ground, which would thus produce a new ſtratum of moraſs over the other, differing indeed principally in its age, and perhaps, as the timber might be different, in the proportions of its component parts.

Now if we ſuppoſe the lowermoſt ſtratum of a moraſs become ignited, like fermenting hay, (after whatever could be carried away by ſolution in water was gone,) what would happen? Certainly the inflammable part, the oil, ſulphur, or bitumen, would burn away and be evaporated in air; and the fixed parts would be left, as clay, lime, and iron; while ſome of the calcareous earth would join with the ſiliceous acid, and produce ſand, or with the argillaceous earth, and produce marl. Thence after many centuries another bed would take fire, but with leſs degree of ignition, and with a greater body of moraſs over it, what then would happen? The bitumen and ſulphur would riſe and might become condenſed under an impervious ſtratum, which might not be ignited, and there form coal of different purities according to its degree of fluidity, which would permit ſome of the clay to ſubſide through it into the place from which it was ſublimed.

Some centuries afterwards another ſimilar proceſs might take place, and either thicken the coal-bed, or produce a new clay-bed, or marl, or ſand, or depoſit iron upon it, according to the concomitant circumſtances above mentioned.

I do not mean to contend that a few maſſes of ſome materials may not have been rolled together by currents, when the mountains were much more elevated than at preſent, and in conſequence the rivers broader and more rapid, and the ſtorms of rain and wind greater both in quantity and force. Some gravel-beds may have been thus waſhed from the mountains; and ſome white clay waſhed from moraſſes into valleys beneath them; and ſome ochres of iron diſſolved and again depoſited by water; and ſome calcareous depoſitions from water, (as the bank for inſtance on which ſtand the houſes at Matlock-bath;) but theſe are of ſmall extent or conſequence compared to the primitive rocks of granite or porphyry which form the nucleus of the earth, or to the immenſe ſtrata of limeſtone which cruſt over the greateſt part of this granite or porphyry; or laſtly to the very extenſive beds of clay, marl, ſandſtone, coal, and iron, which were probably for many millions of years the only parts of our continents and iſlands, which were then elevated above the level of the ſea, and which on that account became covered with vegetation, and thence acquired their later or ſuperincumbent ſtrata, which conſtitute, what ſome have termed, the new world.

There is another ſource of clay, and that of the fineſt kind, from decompoſed granite, this is of a ſnowy white and mixed with ſhining particles of mica, of this kind as in earth from the country of Cherokees. Other kinds are from leſs pure lavas; Mr. Ferber aſſerts that the ſulphureous ſteams from Mount Veſuvius convert the lava into clay.

" The lavas of the antient Solfatara volcano have been undoubtedly of a vitreous nature, and theſe appear at preſent argillaceous. Some fragments of this lava are but half or at one ſide changed into clay, which either is viſcid or ductile, or hard and ſtoney. Clays by fire are deprived of their coherent quality, which cannot be reſtored to them by pulverization, nor by humectation. But the ſulphureous Solfatara ſteams reſtore it, as may be eaſily obſerved on the broken pots wherein they gather the ſal ammoniac; though very well baked and burnt at Naples they are mollified again by the acid ſteams into a viſcid clay which keeps the former fire-burnt colour." Travels in Italy, p. 156.

## NOTE XXI.——ENAMELS.

*Smear'd her huge dragons with metallic hues,*
*With golden purples, and cobaltic blues;*

CANTO II. l. 287.

THE fine bright purples or roſe colours which we ſee on china cups are not producible with any other material except gold, manganeſe indeed gives a purple but of a very different kind.

In Europe the application of gold to theſe purpoſes appears to be of modern invention. Caſſius's diſcovery of the precipitate of gold by tin, and the uſe of that precipitate for colouring glaſs and enamels, are now generally known, but though the precipitate with tin be more ſucceſsful in producing the ruby glaſs, or the colourleſs glaſs which becomes red by ſubſequent ignition, the tin probably contributing to prevent the gold from ſeparating, (which it is very liable to do during the fuſion;) yet, for enamels, the precipitates made by alcaline ſalts anſwer equally well, and give a finer red, the colour produced by the tin precipitate being a bluiſh purple, but with the others a roſe red. I am informed that ſome of our beſt artiſts prefer aurum fulminans, mixing it, before it has become dry, with the white compoſition or enamel flux; when once it is divided by the other matter, it is ground with great ſafety, and without the leaſt danger of exploſion, whether moiſt or dry. The colour is remarkably improved and brought forth by long grinding, which accordingly makes an eſſential circumſtance in the proceſs.

The precipitates of gold, and the colcothar or other red preparations of iron, are called *tender* colours. The heat muſt be no greater than is juſt ſufficient to make the enamel run upon the piece, for if greater, the colours will be deſtroyed or changed to a different kind. When the vitreous matter has juſt become fluid it ſeems as if the coloured metallic calx remained barely *intermixed* with it, like a coloured powder of exquiſite tenuity ſuſpended in water: but by ſtronger fire the calx is *diſſolved*, and metallic colours are altered by *ſolution* in glaſs as well as in acids or alcalies.

The Saxon mines have till very lately almoſt excluſively ſupplied the reſt of Europe with cobalt, or rather with its preparations, zaffre and ſmalt, for the exportation of the ore itſelf is there a capital crime.

Hungary, Spain, Sweden, and ſome other parts of the continent, are now ſaid to afford cobalts equal to the Saxon, and ſpecimens have been diſcovered in our own iſland, both in Cornwall and in Scotland, but hitherto in no great quantity.

Calces of cobalt and of copper differ very materially from thoſe above mentioned in their application for colouring enamels. In thoſe the calx has previouſly acquired the intended colour, a colour which bears a red heat without injury, and all that remains is to fix it on the piece by a vitreous flux. But the blue colour of cobalt, and the green or bluiſh green of copper, are *produced* by vitrification, that is, by *ſolution* in the glaſs, and a ſtrong fire is neceſſary for their perfection. Theſe calces therefore, when mixed with the enamel flux, are melted in crucibles, once or oftener, and the deep coloured opake glaſs, thence reſulting, is ground into unpalpable powder, and uſed for enamel. One part of either of theſe calces is put to ten, ſixteen, or twenty parts of the flux, according to the depth of colour required. The heat of the enamel kiln is only a full red, ſuch as is marked on Mr. Wedgwood's thermometer 6 degrees. It is therefore neceſſary that the flux be ſo adjuſted as to melt in that low heat. The uſual materials are flint, or flint-glaſs, with a due proportion of red-led, or borax, or both, and ſometimes a little tin calx to give opacity.

*Ka-o-lin* is the name given by the Chineſe to their porcelain clay, and *pe-tun-tſe* to the other ingredient in their China ware. Specimens of both theſe have been brought into England, and found to agree in quality with ſome of our own materials. Kaolin is the very ſame with the clay called in Cornwall              and the petuntſe is a granite ſimilar to the Corniſh moorſtone. There are differences, both in the Chineſe petuntſes, and the Engliſh moorſtones; all of them contain micaceous and quartzy particles, in greater or leſs quantity, along with feltſpat, which laſt is the eſſential ingredient for the porcelain manufactory. The only injurious material commonly found in them is iron, which diſcolours the ware in proportion to its quantity, and which our moorſtones are perhaps more frequently tainted with than the Chineſe. Very fine porcelain has been made from Engliſh materials, but the nature of the manufacture renders the proceſs precarious and the profit hazardous; for the ſemivitrification, which conſtitutes porcelain, is neceſſarily accompanied with a degree of ſoftneſs, or ſemifuſion, ſo that the veſſels are liable to have their forms altered in the kiln, or to run together with any accidental augmentations of the fire.

## NOTE XXII.—PORTLAND VASE.

*Or bid mortality rejoice or mourn*
*O'er the fine forms of Portland's myſtic urn.*
CANTO II. l. 321.

THE celebrated funereal vaſe, long in poſſeſſion of the Barberini family, and lately purchaſed by the Duke of Portland for a thouſand guineas, is about ten inches high and ſix in diameter in the broadeſt part. The figures are of the moſt exquiſite workmanſhip in bas relief of white opake glaſs, raiſed on a ground of deep blue glaſs, which appears black except when held againſt the light. Mr. Wedgwood is of opinion from many circumſtances that the figures have been made by cutting away the external cruſt of white opake glaſs, in the manner the fineſt cameo's have been produced, and that it muſt thence have been the labour of a great many years. Some antiquarians have placed the time of its production many centuries before the chriſtian æra; as ſculpture was ſaid to have been declining in reſpect to its excellence in the time of Alexander the Great. See an account of the Barberini or Portland vaſe by M. D'Hancarville, and by Mr. Wedgwood.

Many opinions and conjectures have been publiſhed concerning the figures on this celebrated vaſe. Having carefully examined one of Mr. Wedgwood's beautiful copies of this wonderful production of art, I ſhall add one more conjecture to the number.

Mr. Wedgwood has well obſerved that it does not ſeem probable that the Portland vaſe was purpoſely made for the aſhes of any particular perſon deceaſed, becauſe many years muſt have been neceſſary for its production. Hence it may be concluded, that the ſubject of its embelliſhments is not private hiſtory but of a general nature. This ſubject appears to me to be well choſen, and the ſtory to be finely told; and that it repreſents what in antient times engaged the attention of philoſophers, poets, and heroes, I mean a part of the Eleuſinian myſteries.

Theſe myſteries were invented in Ægypt, and afterwards transferred to Greece, and flouriſhed more particularly at Athens, which was at the ſame time the ſeat of the fine arts. They conſiſted of ſcenical exhibitions repreſenting and inculcating the expectation of a future life after death, and on this account were encouraged by the government, inſomuch that the Athenian laws puniſhed a diſcovery of their ſecrets with death. Dr. Warburton has with great learning and ingenuity ſhewn that the deſcent of Æneas into hell, deſcribed in the Sixth Book of Virgil, is a poetical account of the repreſentations of the future ſtate in the Eleuſinian myſteries. Divine Legation, Vol. I. p. 210.

And though ſome writers have differed in opinion from Dr. Warburton on this ſubject, becauſe Virgil has introduced ſome of his own heroes into the Elyſian fields, as Deiphobus, Palinurus, and Dido, in the ſame manner as Homer had done before him, yet it is agreed that the received notions about a future ſtate were exhibited in theſe myſteries, and as theſe poets deſcribed thoſe received notions, they may be ſaid, as far as theſe religious doctrines were concerned, to have deſcribed the myſteries.

Now as theſe were emblematic exhibitions they muſt have been as well adapted to the purpoſes of ſculpture as of poetry, which indeed does not ſeem to have been uncommon, ſince one compartment of figures in the ſhield of Æneas repreſented the regions of Tartarus. Æn. Lib. X. The proceſſion of torches, which according to M. De St. Croix was exhibited in theſe myſteries, is ſtill to be ſeen in baſſo relievo, diſcovered by Spon and Wheler. Memoires ſur le Myſteres par De St. Croix. 1784. And it is very probable that the beautiful gem repreſenting the marriage of Cupid and Pſyche, as deſcribed by Apuleus, was originally deſcriptive of another part of the exhibitions in theſe myſteries, though afterwards it became a common ſubject of antient art. See Divine Legat. Vol. I. p. 323. What ſubject could have been imagined ſo ſublime for the ornaments of a funereal urn as the mortality of all things and their reſuſcitation? Where could the deſigner be ſupplied with emblems for this purpoſe, before the Chriſtian æra, but from the Eleuſinian myſteries?

1. The exhibitions of the myſteries were of two kinds, thoſe which the people were permitted to ſee, and thoſe which were only ſhewn to the initiated. Concerning the latter, Ariſtides calls them "the moſt ſhocking and moſt raviſhing repreſentations." And Stobœus aſſerts that the initiation into the grand myſteries exactly reſembles death. Divine Legat. Vol. I. p. 280, and p. 272. And Virgil in his entrance to the ſhades below, amongſt other things of terrible form, mentions death. Æn. VI. This part of the exhibition ſeems to be repreſented in one of the compartments of the Portland vaſe.

Three figures of exquiſite workmanſhip are placed by the ſide of a ruined column whoſe capital is fallen off, and lies at their feet with other disjointed ſtones, they ſit on looſe piles of ſtone beneath a tree, which has not the leaves of any evergreen of this climate, but may be ſuppoſed to be an elm, which Virgil places near the entrance of the infernal regions, and adds, that a dream was believed to dwell under every leaf of it. Æn. VI. l. 281. In the midſt of this group reclines a female figure in a dying attitude, in which extreme languor is beautifully repreſented, in her hand is an inverted torch, an antient emblem of extinguiſhed life, the elbow of the ſame arm reſting on a ſtone ſupports her as ſhe ſinks, while the other hand is raiſed and thrown over her drooping head, in ſome meaſure ſuſtaining it and gives with great art the idea of fainting laſſitude. On the right of her ſits a man, and on the left a woman, both ſupporting themſelves on their arms, as people are liable to do when they are thinking intenſely. They have their backs towards the dying figure, yet with their faces turned towards her, as if ſeriouſly contemplating her ſituation, but without ſtretching out their hands to aſſiſt her.

This central figure then appears to me to be an hieroglyphic or Eleuſinian emblem of MORTAL LIFE, that is, the lethum, or death, mentioned by Virgil amongſt the terrible things exhibited at the beginning of the myſteries. The inverted torch ſhews the figure to be emblematic, if it had been deſigned to repreſent a real perſon in the act of dying there had been no neceſſity for the expiring torch, as the dying figure alone would have been ſufficiently intelligible;—it would have been as abſurd as to have put an inverted torch into the hand of a real perſon at the time of his expiring. Beſides if this figure had repreſented a real dying perſon would not the other figures, or one of them at leaſt, have ſtretched out a hand to ſupport her, to have eaſed her fall among looſe ſtones, or to have ſmoothed her pillow? Theſe circumſtances evince that the figure is an emblem, and therefore could not be a repreſentation of the private hiſtory of any particular family or event.

The man and woman on each ſide of the dying figure muſt be conſidered as emblems, both from their ſimilarity of ſituation and dreſs to the middle figure, and their being grouped along with it. Theſe I think are hieroglyphic or Eleuſinian emblems of HUMANKIND, with their backs toward the dying figure of MORTAL LIFE, unwilling to aſſociate with her, yet turning back their ſerious and attentive countenances, curious indeed to behold, yet ſorry to contemplate their latter end. Theſe figures bring ſtrongly to one's mind the Adam and Eve of ſacred writ, whom ſome have ſuppoſed to have been allegorical or hieroglyphic perſons of Ægyptian origin, but of more antient date, amongſt whom I think is Dr. Warburton. According to this opinion Adam and Eve were the names of two hieroglyphic figures repreſenting the early ſtate of mankind; Abel was the name of an hieroglyphic figure repreſenting the age of paſturage, and Cain the name of another hieroglyphic ſymbol repreſenting the age of agriculture, at which time the uſes of iron were diſcovered. And as the people who cultivated the earth and built houſes would increaſe in numbers much faſter by their greater production of food, they would readily conquer or deſtroy the people who were ſuſtained by paſturage, which was typified by Cain ſlaying Abel.

2. On the other compartment of this celebrated vaſe is exhibited an emblem of immortality, the repreſentation of which was well known to conſtitute a very principal part of the ſhews at the Eleuſinian myſteries, as Dr. Warburton has proved by variety of authority. The habitation of ſpirits or ghoſts after death was ſuppoſed by the antients to be placed beneath the earth, where Pluto reigned, and diſpenſed rewards or puniſhments. Hence the firſt figure in this group is of the MANES or GHOST, who having paſſed through an open portal is deſcending into a duſky region, pointing his toe with timid and unſteady ſtep, feeling as it were his way in the gloom. This portal Æneas enters, which is deſcribed by Virgil,—patet atri janua ditis, Æn. VI. l. 126; as well as the eaſy deſcent,—facilis deſcenſus Averni. Ib. The darkneſs at the entrance to the ſhades is humorouſly deſcribed by Lucian. Div. Legat. Vol. I. p. 241. And the horror of the gates of hell was in the time of Homer become a proverb; Achilles ſays to Ulyſſes, "I hate a liar worſe than the gates of hell;" the ſame expreſſion is uſed in Iſaiah, ch. xxxviii. v. 10. The MANES or GHOST appears lingering and fearful, and wiſhes to drag after him a part of his mortal garment, which however adheres to the ſide of the portal through which he has paſſed. The beauty of this allegory would have been expreſſed by Mr. Pope, by "We feel the ruling paſſion ſtrong in death."

A little lower down in the group the manes or ghoſt is received by a beautiful female, a ſymbol of IMMORTAL LIFE. This is evinced by her fondling between her knees a large and playful ſerpent, which from its annually renewing its external ſkin has from great antiquity, even as early as the fable of Prometheus, been eſteemed an emblem of renovated youth. The ſtory of the ſerpent acquiring immortal life from the aſs of Prometheus, who carried it on his back, is told in Bacon's Works, Vol. V. p. 462. Quarto edit. Lond. 1778. For a ſimilar purpoſe a ſerpent was wrapped round the large hieroglyphic egg in the temple of Dioſcuri, as an emblem of the renewal of life from a ſtate of death. Briant's Mythology, Vol. II. p. 359. ſec. edit. On this account alſo the ſerpent was an attendant on Æſculapius, which ſeems to have been the name of the hieroglyphic figure of medicine. This ſerpent ſhews this figure to be an emblem, as the torch ſhewed the central figure of the other compartment to be an emblem, hence they agreeably correſpond, and explain each other, one repreſenting MORTAL LIFE, and the other IMMORTAL LIFE.

This emblematic figure of immortal life ſits down with her feet towards the figure of Pluto, but, turning back her face towards the timid ghoſt, ſhe ſtretches forth her hand, and taking hold of his elbow, ſupports his tottering ſteps, as well as encourages him to advance, both which circumſtances are thus with wonderful ingenuity brought to the eye. At the ſame time the ſpirit looſely lays his hand upon her arm, as one walking in the dark would naturally do for the greater certainty of following his conductreſs, while the general part of the ſymbol of IMMORTAL LIFE, being turned toward the figure of Pluto, ſhews that ſhe is leading the phantom to his realms.

In the Pamphili gardens at Rome, Perſeus in aſſiſting Andromeda to deſcend from the rock takes hold of her elbow to ſteady or ſupport her ſtep, and ſhe lays her hand looſely on his arm as in this figure. Admir. Roman. Antiq.

The figure of PLUTO can not be miſtaken, as is agreed by moſt of the writers who have mentioned this vaſe; his griſley beard, and his having one foot buried in the earth, denotes the infernal monarch. He is placed at the loweſt part of the group, and reſting his chin on his hand, and his arm upon his knee, receives the ſtranger-ſpirit with inquiſitive attention; it was before obſerved that when people think attentively they naturally reſt their bodies in ſome eaſy attitude, that more animal power may be employed on the thinking faculty. In this group of figures there is great art ſhewn in giving an idea of a deſcending plain, viz. from earth to Elyſium, and yet all the figures are in reality on an horizontal one. This wonderful deception is produced firſt by the deſcending ſtep of the manes or ghoſt; ſecondly, by the arm of the ſitting figure of immortal life being raiſed up to receive him as he deſcends; and laſtly, by Pluto having one foot ſunk into the earth.

There is yet another figure which is concerned in conducting the manes or ghoſt to the realms of Pluto, and this is LOVE. He precedes the deſcending ſpirit on expanded wings, lights him with his torch, and turning back his beautiful countenance beckons him to advance. The antient God of love was of much higher dignity than the modern Cupid. He was the firſt that came out of the great egg of night, (Heſiod. Theog. V. CXX. Briant's Mythol. Vol. II. p. 348.) and is ſaid to poſſeſs the keys of the ſky, ſea, and earth. As he therefore led the way into this life, he ſeems to conſtitute a proper emblem for leading the way to a future life. See Bacon's works. Vol. I. p. 568. and Vol. III. p. 582. Quarto edit.

The introduction of love into this part of the myſteries requires a little further explanation. The Pſyche of the Ægyptians was one of their moſt favourite emblems, and repreſented the ſoul, or a future life; it was originally no other than the aurelia, or butterfly, but in after time, was repreſented by a lovely female child with the beautiful wings of that inſect. The aurelia, after its firſt ſtage as an eruca or caterpillar, lies for a ſeaſon in a manner dead, and is incloſed in a ſort of coffin, in this ſtate of darkneſs it remains all the winter, but at the return of ſpring it burſts its bonds and comes out with new life, and in the moſt beautiful attire. The Ægyptians thought this a very proper picture of the ſoul of man, and of the immortality to which it aſpired. But as this was all owing to divine Love, of which EROS was an emblem, we find this perſon frequently introduced as a concomitant of the ſoul in general or Pſyche. (Bryant's Mythol. Vol. II. p. 386.) EROS, or divine Love, is for the ſame reaſon a proper attendant on the manes or ſoul after death, and much contributes to tell the ſtory, that is, to ſhew that a ſoul or manes is deſigned by the deſcending figure. From this figure of Love M. D'Hancarville imagines that Orpheus and Eurydice are typified under the figure of the manes and immortal life as above deſcribed. It may be ſufficient to anſwer, firſt, that Orpheus is always repreſented with a lyre, of which there are prints of four different gems in Spence's Polymetis, and Virgil ſo deſcribes him, *Æn. VI.* cytharâ fretus. And ſecondly, that it is abſurd to ſuppoſe that Eurydice was fondling and playing with a ſerpent that had ſlain her. Add to this that Love ſeems to have been an inhabitant of the infernal regions, as exhibited in the myſteries, for Claudian, who treats more openly of the Eleuſinian myſteries, when they were held in leſs veneration, invokes the deities to diſcloſe to him their ſecrets, and amongſt other things by what torch Love ſoftens Pluto.

> Dii, quibus in numerum, &c.
> Vos mihi ſacrarum penetralia pandite rerum,
> Et veſtri ſecreta poli, quâ lampade Ditem
> Flexit amor.

In this compartment there are two trees, whoſe branches ſpread over the figures, one of them has ſmoother leaves like ſome evergreens, and might thence be ſuppoſed to have ſome alluſion to immortality, but they may perhaps have been deſigned only as ornaments, or to relieve the figures, or becauſe it was in groves, where theſe myſteries were originally celebrated. Thus Homer ſpeaks of the woods of Proſerpine, and mentions many trees in Tartarus, as preſenting their fruits to Tantalus;

Virgil ſpeaks of the pleaſant groves of Elyſium; and in Spence's Polymetis there are prints of two antient gems, one of Orpheus charming Cerberus with his lyre, and the other of Hercules binding him in a cord, each of them ſtanding by a tree. Polymet. p. 284. As however theſe trees have all different foliage ſo clearly marked by the artiſt, they may have had ſpecific meanings in the exhibitions of the myſteries, which have not reached poſterity, of this kind ſeem to have been the tree of knowledge of good and evil, and the tree of life, in ſacred writ, both which muſt have been emblematical or allegorical. The maſks, hanging to the handles of the vaſe, ſeem to indicate that there is a concealed meaning in the figures beſides their general appearance. And the prieſteſs at the bottom, which I come now to deſcribe, ſeems to ſhew this concealed meaning to be of the ſacred or Eleuſinian kind.

3. The figure on the bottom of the vaſe is on a larger ſcale than the others, and leſs finely finiſhed, and leſs elevated, and as this bottom part was afterwards cemented to the upper part, it might be executed by another artiſt for the ſake of expedition, but there ſeems no reaſon to ſuppoſe that it was not originally deſigned for the upper part of it as ſome have conjectured. As the myſteries of Ceres were celebrated by female prieſts, for Porphyrius ſays the antients called the prieſteſſes of Ceres, Meliſſai, or bees, which were emblems of chaſtity. Div. Leg. Vol. I. p. 235. And as, in his Satire againſt the ſex, Juvenal ſays, that few women are worthy to be prieſteſſes of Ceres. Sat. VI. the figure at the bottom of the vaſe would ſeem to repreſent a PRIESTESS or HIEROPHANT, whoſe office it was to introduce the initiated, and point out to them, and explain the exhibitions in the myſteries, and to exclude the uninitiated, calling out to them, "Far, far retire, ye profane!" and to guard the ſecrets of the temple. Thus the introductory hymn ſung by the hierophant, according to Euſebius, begins, "I will declare a ſecret to the initiated, but let the doors be ſhut againſt the profane." Div. Leg. Vol. I. p. 177. The prieſteſs or hierophant appears in this figure with a cloſe hood, and dreſſed in linen, which ſits cloſe about her; except a light cloak, which flutters in the wind. Wool, as taken from ſlaughtered animals, was eſteemed profane by the prieſts of Ægypt, who were always dreſſed in Linen. Apuleus, p. 64. Div. Leg. Vol. I. p. 318. Thus Eli made for Samuel a linen ephod. Samuel i. 3.

Secrecy was the foundation on which all myſteries reſted, when publicly known they ceaſed to be myſteries; hence a diſcovery of them was not only puniſhed with death by the Athenian law; but in other countries a diſgrace attended the breach of a ſolemn oath. The prieſteſs in the figure before us has her finger pointing to her lips as an emblem of ſilence. There is a figure of Harpocrates, who was of Ægyptian origin, the ſame as Orus, with the lotus on his head, and with his finger pointing to his lips not preſſed upon them, in Bryant's Mythol. Vol. II. p. 398, and another female figure ſtanding on a lotus, as if juſt riſen from the Nile, with her finger in the ſame attitude, theſe ſeem to have been repreſentations or emblems of males and female prieſts of the ſecret myſteries. As theſe ſort of emblems were frequently changed by artiſts for their more elegant exhibition, it is poſſible the foliage over the head of this figure may bear ſome analogy to the lotus above mentioned.

This figure of ſecrecy ſeems to be here placed, with great ingenuity, as a caution to the initiated, who might underſtand the meaning of the emblems round the vaſe, not to divulge it. And this circumſtance ſeems to account for there being no written explanation extant, and no tradition concerning theſe beautiful figures handed down to us along with them.

Another explanation of this figure at the bottom of the vaſe would ſeem to confirm the idea that the baſſo relievos round its ſides are repreſentations of a part of the myſteries, I mean that it is the head of ATIS. Lucian ſays that Atis was a young man of Phrygia, of uncommon beauty, that he dedicated a temple in Syria to Rhea, or Cybele, and firſt taught her myſteries to the Lydians, Phrygians, and Samothracians, which myſteries he brought from India. He was afterwards made a eunuch by Rhea, and lived like a woman, and aſſumed a feminine habit, and in that garb went over the world teaching her ceremonies and myſteries. Dict. par M. Danet, art. Atis. As this figure is covered with clothes, while thoſe on the ſides of the vaſe are naked, and has a Phrygian cap on the head, and as the form and features are ſo ſoft, that it is difficult to ſay whether it be a male or female figure, there is reaſon to conclude, 1. that it has reference to ſome particular perſon of ſome particular country; 2. that this perſon is Atis, the firſt great hierophant, or teacher of myſteries, to whom M. De la Chauſſe ſays the figure itſelf bears a reſemblance. Muſeo. Capitol. Tom. IV. p. 402.

In the Muſeum Etruſcum, Vol. I. plate 96, there is the head of Atis with feminine features, clothed with a Phrygian cap, and riſing from very broad foliage, placed on a kind of term ſupported by the paw of a lion. Goreus in his explanation of the figure ſays that it is placed on a lion's foot becauſe that animal was ſacred to Cybele, and that it riſes from very broad leaves becauſe after he became an eunuch he determined to dwell in the groves. Thus the foliage, as well as the cap and feminine features, confirm the idea of this figure at the bottom of the vaſe repreſenting the head of Atis the firſt great hierophant, and that the figures on the ſides of the vaſe are emblems from the antient myſteries.

I beg leave to add that it does not appear to have been uncommon amongſt the antients to put allegorical figures on funeral vaſes. In the Pamphili palace at Rome there is an elaborate repreſentation of Life and of Death, on an antient ſarcophagus. In the firſt Prometheus is repreſented making man, and Minerva is placing a butterfly, or the ſoul, upon his head. In the other compartment Love extinguiſhes his torch in the boſom of the dying figure, and is receiving the butterfly, or Pſyche, from him, with a great number of complicated emblematic figures grouped in very bad taſte. Admir. Roman. Antiq.

## NOTE XXIII.—COAL.

*Whence ſable Coal his maſſy couch extends,*
*And ſtars of gold the ſparkling Pyrite blends.*

Canto II. l. 345.

TO elucidate the formation of coal-beds I ſhall here deſcribe a fountain of foſſil tar, or petroleum, diſcovered lately near Colebrook Dale in Shropſhire, the particulars of which were ſent me by Dr. Robert Darwin of Shrewſbury.

About a mile and a half below the celebrated iron-bridge, conſtructed by the late Mr. Darby near Colebrook Dale, on the eaſt ſide of the river Severn, as the workmen in October 1786 were making a ſubterranean canal into the mountain, for the more eaſy acquiſiton and conveyance of the coals which lie under it, they found an oozing of liquid bitumen, or petroleum; and as they proceeded further, cut through ſmall cavities of different ſizes from which the bitumen iſſued. From ten to fifteen barrels of this foſſil tar, each barrel containing thirty-two gallons, were at firſt collected in a day, which has ſince however gradually diminiſhed in quantity, ſo that at preſent the product is about ſeven barrels in fourteen days.

The mountain, into which this canal enters, conſiſts of ſiliceous ſand, in which however a few marine productions, apparently in their recent ſtate, have been found, and are now in the poſſeſſion of Mr. WILLIAM REYNOLDS of Ketly Bank. About three hundred yards from the entrance into the mountain, and about twenty-eight yards below the ſurface of it, the tar is found oozing from the ſand-rock above into the top and ſides of the canal.

Beneath the level of this canal a ſhaft has been ſunk through a grey argillaceous ſubſtance, called in this country clunch, which is ſaid to be a pretty certain indication of coal; beneath this lies a ſtratum of coal, about two or three inches thick, of an inferior kind, yielding little flame in burning, and leaving much aſhes, below this is a rock of a harder texture; and beneath this are found coals of an excellent quality; for the purpoſe of procuring which with greater facility the canal, or horizontal aperture, is now making into the mountain. July, 1788.

Beneath theſe coals in ſome places is found ſalt water, in other parts of the adjacent country there are beds of iron-ſtone, which alſo contain ſome bitumen in a leſs fluid ſtate, and which are about on a level with the new canal, into which the foſſil tar oozes, as above deſcribed.

There are many intereſting circumſtances attending the ſituation and accompaniment of this fountain of foſſil tar, tending to develope the manner of its production. 1. As the canal paſſing into the mountain runs over the beds of coals, and under the reſervoir of petroleum, it appears that a *natural diſtillation* of this foſſil in the bowels of the earth muſt have taken place at ſome early period of the world, ſimilar to the artificial diſtillation of coal, which has many years been carried on in this place on a ſmaller ſcale above ground. When this reſervoir of petroleum was cut into, the ſlowneſs of its exſudation into the canal was not only owing to its viſcidity, but to the preſſure of the atmoſphere, or to the neceſſity there was that air ſhould at the ſame time inſinuate itſelf into the ſmall cavities from which the petroleum deſcended. The exiſtence of ſuch a diſtillation at ſome antient time is confirmed by the thin ſtratum of coal beneath the canal, (which covers the hard rock,) having been deprived of its foſſil oil, ſo as to burn without flame, and thus to have become a natural coak, or foſſil charcoal, while the petroleum diſtilled from it is found in the cavities of the rock above it.

There are appearances in other places, which favour this idea of the natural diſtillation of petroleum, thus at Matlock in Derbyſhire a hard bitumen is found adhering to the ſpar in the clefts of the lime-rocks in the form of round drops about the ſize of peas; which could perhaps only be depoſited there in that form by ſublimation.

2. The ſecond deduction, which offers itſelf, is, that theſe beds of coal have been *expoſed to a conſiderable degree of heat*, ſince the petroleum above could not be ſeparated, as far as we know, by any other means, and that the good quality of the coals beneath the hard rock was owing to the impermeability of this rock to the bituminous vapour, and to its preſſure being too great to permit its being removed by the elaſticity of that vapour. Thus from the degree of heat, the degree of preſſure, and the permeability of the ſuperincumbent ſtrata, many of the phenomena attending coal-beds receive an eaſy explanation, which much accords with the ingenious theory of the earth by Dr. Hutton. Tranſ. of Edinb. Vol. I.

In ſome coal works the fuſion of the ſtrata of coal has been ſo ſlight, that there remains the appearance of ligneus fibres, and the impreſſion of leaves, as at Bovey near Exeter, and even ſeeds of vegetables, of which I have had ſpecimens from the collieries near Poleſworth in Warwickſhire. In ſome, where the heat was not very intenſe and the incumbent ſtratum not permeable to vapour, the foſſil oil has only riſen to the upper part of the coal-bed, and has rendered that much more inflammable than the lower parts of it, as in the collieries near Beaudeſert, the ſeat of the EARL OF UXBRIDGE in Staffordſhire, where the upper ſtratum is a perfect cannel, or candle-coal, and the lower one of an inferior quality. Over the coal-beds near Sir H. HARPUR's houſe in Derbyſhire a thin lamina of aſphaltum is found in ſome places near the ſurface of the earth, which would ſeem to be from a diſtillation of petroleum from the coals below, the more fluid part of which had in proceſs of time exhaled, or been conſolidated by its abſorption of air. In other coal-works the upper part of the ſtratum is of a worſe kind than the lower one, as at Alfreton and Denbigh in Derbyſhire, owing to the ſupercumbent ſtratum having permitted the exhalation of a great part of the petroleum; whilſt at Widdrington in Northumberland there is firſt a ſeam of coal about ſix inches thick of no value, which lies under about four fathom of clay, beneath this is a white freeſtone, then a hard ſtone, which the workmen there call a whin, then two fathoms of clay, then another white ſtone, and under that a vein of coals three feet nine inches thick, of a ſimilar nature to the Newcaſtle coal. Phil. Tranſ. Abridg. Vol. VI. plate II. p. 192. The ſimilitude between the circumſtances of this colliery, and of the coal beneath the fountain of tar above deſcribed, renders it highly probable that this upper thin ſeam of coal has ſuffered a ſimilar diſtillation, and that the inflammable part of it had either been received into the clay above in the form off ulphur, which when burnt in the open air would produce alum; or had been diſſipated for want of a receiver, where it could be condenſed. The former opinion is perhaps in this caſe more probable, as in ſome other coal-beds, of which I have procured accounts, the ſurface of the coal beneath clunch or clay is of an inferior quality, as at Weſt Hallum in Nottinghamſhire. The clunch probably from hence acquires its inflammable part, which on calcination becomes vitriolic acid. I gathered pieces of clunch converted partially into alum at a colliery near Bilſton, where the ground was ſtill on fire a few years ago.

The heat, which has thus pervaded the beds of moraſs, ſeems to have been the effect of the fermentation of their vegetable materials; as new hay ſometimes takes fire even in ſuch very ſmall maſſes from the ſugar it contains, and ſeems hence not to have been attended with any expulſion of lava, like the deeper craters of volcanos ſituated in beds of granite.

3. The marine ſhells found in the looſe ſand-rock above this reſervoir of petroleum, and the coal-beds beneath it, together with the exiſtence of ſea-ſalt beneath theſe coals, prove that theſe coal beds have been *at the bottom of the ſea*, during ſome remote period of time, and were afterwards raiſed into their preſent ſituation by ſubterraneous expanſions of vapour. This doctrine is further ſupported by the marks of violence, which ſome coal-beds received at the time they were raiſed out of the ſea, as in the collieries at Mendip in Somerſetſhire. In theſe there are ſeven ſtrata of coals, equitant upon each other, with beds of clay and ſtone intervening; amongſt which clay are found ſhells and fern branches. In one part of this hill the ſtrata are disjoined, and a quantity of heterogeneous ſubſtances fill up the chaſm which disjoins them, on one ſide of this chaſm the ſeven ſtrata of coal are ſeen correſponding in reſpect to their reciprocal thickneſs and goodneſs with the ſeven ſtrata on the other ſide of the cavity, except that they have been elevated ſeveral yards higher. Phil. Tranſ. No. 360. abridg. Vol. V. p. 237.

The cracks in the coal-bed near Ticknall in Derbyſhire, and in the ſand-ſtone rock over it, in both of which ſpecimens of lead-ore and ſpar are found, confirm this opinion of their having been forcibly raiſed up by ſubterraneous fires. Over the colliery at Brown-hills near Lichfield, there is a ſtratum of gravel on the ſurface of the ground; which may be adduced as another proof to ſhew that thoſe coals had ſome time been beneath the ſea, or the bed of a river. Nevertheleſs, theſe arguments only apply to the collieries above mentioned, which are few compared with thoſe which bear no marks of having been immerſed in the ſea.

On the other hand the production of coals from moraſſes, as deſcribed in note XX. is evinced from the vegetable matters frequently found in them, and in the ſtrata over them; as fern-leaves in nodules of iron-ore, and from the bog-ſhells or freſh water muſcles ſometimes found over them, of both which I have what I believe to be ſpecimens; and is further proved from ſome parts of theſe beds being only in part tranſformed to coal; and the other part ſtill retaining not only the form, but ſome of the properties of wood; ſpecimens of which are not unfrequent in the cabinets of the curious, procured from Loch Neigh in Ireland, from Bovey near Exeter, and other places; and from a famous cavern called the Temple of the Devil, near the town of Altorf in Franconia, at the foot of a mountain covered with pine and ſavine, in which are found large coals reſembling trees of ebony; which are ſo far mineralized as to be heavy and compact; and ſo to effloreſce with pyrites in ſome parts as to crumble to pieces; yet from other parts white aſhes are produced on calcination, from which *fixed alcali* is procured; which evinces their vegetable origin. (Dict. Raiſonné, art. Charbon.) To theſe may be added another argument from the oil which is diſtilled from coals, and which is analogous to vegetable oil, and does not exiſt in any bodies truly mineral. Keir's Chemical Dictionary, art. Bitumen.

Whence it would appear, that though moſt collieries with their attendant ſtrata of clay, ſand-ſtone, and iron, were formed on the places where the vegetables grew, from which they had their origin; yet that other collections of vegetable matter were waſhed down from eminences by currents of waters into the beds of rivers, or the neighbouring ſeas, and were there accumulated at different periods of time, and underwent a great degree of heat from their fermentation, in the ſame manner as thoſe beds of moraſs which had continued on the plains where they were produced. And that by this fermentation many of them had been raiſed from the ocean with ſand and ſea-ſhells over them; and others from the beds of rivers with accumulations of gravel upon them.

4. For the purpoſe of bringing this hiſtory of the products of moraſſes more diſtinctly to the eye of the reader, I ſhall here ſubjoin two or three accounts of ſinking or boring for coals, out of above twenty which I have procured from various places, though the terms are not very intelligible, being the language of the overſeers of coal-works.

1. *Whitfield mine* near the Pottery in Staffordſhire. Soil 1 foot. brick-clay 3 feet. ſhale 4. metal which is hard brown and falls in the weather 42. coal 3. warrant clay 6. brown gritſtone 36. coal 3½. warrant clay 3½. baſs and metal 53½. hardſtone 4. ſhaly baſs 1½. coal 4. warrant clay, depth unknown. in all about 55 yards.

2. *Coal-mine at Alfreton* in Derbyſhire. Soil and clay 7 feet. fragments of ſtone 9. bind 13. ſtone 6. bind 34. ſtone 5. bind 2. ſtone 2. bind 10. coal 1½. bind 1½. ſtone 37. bind 7. ſoft coal 3. bind 3. ſtone 20. bind 16. coal 7½. in all about 61 yards.

3. *A baſſet coal-mine at Woolarton* in Nottinghamſhire. Sand and gravel 6 feet. bind 21. ſtone 10. ſmut or effete coal 1. clunch 4. bind 21. ſtone 18. bind 18. ſtone-bind 15. ſoft coal 2. clunch and bind 21. coal 7. in all about 48 yards.

4. *Coal-mine at Weſt-Hallam* in Nottinghamſhire. Soil and clay 7 feet. bind 48. ſmut 1½. clunch 4. bind 3. ſtone 2. bind 1. ſtone 1. bind 3. ſtone 1. bind 16. ſhale 2. bind 12. ſhale 3. clunch, ſtone, and a bed of cank 54. ſoft coal 4. clay and dun 1. ſoft coal 4½. clunch and bind 21. coal 1. broad bind 26. hard coal 6. in all about 74 yards.

As theſe ſtrata generally lie inclined, I ſuppoſe parallel with the limeſtone on which they reſt, the upper edges of them all come out to day, which is termed baſſetting; when the whole maſs was ignited by its fermentation, it is probable that the inflammable part of ſome ſtrata might thus more eaſily eſcape than of others in the form of vapour; as dews are known to ſlide between ſuch ſtrata in the production of ſprings; which accounts for ſome coal-beds being ſo much worſe than others. See note XX.

## NOTE XXIV.—GRANITE.

*Climb the rude ſteeps, the Granite-cliffs ſurround.*

CANTO II. l. 522.

THE loweſt ſtratum of the earth which human labour has arrived to, is granite; and of this likewiſe conſiſts the higheſt mountains of the world. It is known under variety of names according to ſome difference in its appearance or compoſition, but is now generally conſidered by philoſophers as a ſpecies of lava; if it contains quartz, felt-ſpat, and mica in diſtinct cryſtals, it is called granite; which is found in Cornwall in rocks; and in looſe ſtones in the gravel near Drayton in Shropſhire, in the road towards Newcaſtle. If theſe parts of the compoſition be leſs diſtinct, or if only two of them be viſible to the eye, it is termed porphyry, trap, whinſtone, moorſtone, ſlate. And if it appears in a regular angular form, it is called baſaltes. The affinity of theſe bodies has lately been further well eſtabliſhed by Dr. Beddoes in the Phil. Tranſ. Vol. LXXX.

Theſe are all eſteemed to have been volcanic productions that have undergone different degrees of heat; it is well known that in Papin's digeſter water may be made red hot by confinement, and will then diſſolve many bodies which otherwiſe are little or not at all acted upon by it. From hence it may be conceived, that under immenſe preſſure of ſuperincumbent materials, and by great heat, theſe maſſes of lava may have undergone a kind of aqueous ſolution, without any tendency to vitrification, and might thence have a power of cryſtallization, whence all the varieties above mentioned from the different proportion of the materials, or the different degrees of heat they may have undergone in this aqueous ſolution. And that the uniformity of the mixture of the original earths, as of lime, argil, ſilex, magneſia, and barytes, which they contain, was owing to their boiling together a longer or ſhorter time before their elevation into mountains. See note XIX. art. 8.

The ſeat of volcanos ſeems to be principally, if not entirely, in theſe ſtrata of granite; as many of them are ſituated on granite mountains, and throw up from time to time ſheets of lava which run down over the preceding ſtrata from the ſame origin; and in this they ſeem to differ from the heat which has ſeparated the clay, coal, and ſand in moraſſes, which would appear to have riſen from a kind of fermentation, and thus to have pervaded the whole maſs without any expuition of lava.

All the lavas from Veſuvius contain one fourth part of iron, (Kirwan's Min.) and all the five primitive earths, viz. calcareous, argillaceous, ſiliceous, barytic, and magneſian earths, which are alſo evidently produced now daily from the recrements of animal and vegetable bodies. What is to be thence concluded? Has the granite ſtratum in very antient times been produced like the preſent calcareous and ſiliceous maſſes, according to the ingenious theory of Dr. Hutton, who ſays new continents are now forming at the bottom of the ſea to riſe in their turn, and that thus the terraqueous globe has been, and will be, eternal? Or ſhall we ſuppoſe that this internal heated maſs of granite, which forms the nucleus of the earth, was a part of the body of the ſun before it was ſeparated by an exploſion? Or was the ſun originally a planet, inhabited like ours, and a ſatellite to ſome other greater ſun, which has long been extinguiſhed by diffuſion of its light, and around which the preſent ſun continues to revolve, according to a conjecture of the celebrated Mr. Herſchell, and which conveys to the mind a moſt ſublime idea of the progreſſive and increaſing excellence of the works of the Creator of all things?

For the more eaſy comprehenſion of the facts and conjectures concerning the ſituation and production of the various ſtrata of the earth, I ſhall here ſubjoin a ſuppoſed ſection of the globe, but without any attempt to give the proportions of the parts, or the number of them, but only their reſpective ſituation over each other, and a geological recapitulation.

## GEOLOGICAL RECAPITULATION.

1. The earth was projected along with the other primary planets from the ſun, which is ſuppoſed to be on fire only on its ſurface, emitting light without much internal heat like a ball of burning camphor.

2. The rotation of the earth round its axis was occaſioned by its greater friction or adheſion to one ſide of the cavity from which it was ejected; and from this rotation it acquired its ſpheroidical form. As it cooled in its aſcent from the ſun its nucleus became harder; and its attendant vapours were condenſed, forming the ocean.

3. The maſſes or mountains of granite, porphery, baſalt, and ſtones of ſimilar ſtructure, were a part of the original nucleus of the earth; or conſiſt of volcanic productions ſince formed.

4. On this nucleus of granite and baſaltes, thus covered by the ocean, were formed the calcareous beds of limeſtone, marble, chalk, ſpar, from the exuviæ of marine animals; with the flints, or chertz, which accompany them. And were ſtratified by their having been formed at different and very diſtant periods of time.

5. The whole terraqueous globe was burſt by central fires; iſlands and continents were raiſed, conſiſting of granite or lava in ſome parts, and of limeſtone in others; and great vallies were ſunk, into which the ocean retired.

6. During theſe central earthquakes the moon was ejected from the earth, cauſing new tides; and the earth's axis ſuffered ſome change in its inclination, and its rotatory motion was retarded.

7. On ſome parts of theſe iſlands and continents of granite or limeſtone were gradually produced extenſive moraſſes from the recrements of vegetables and of land animals; and from theſe moraſſes, heated by fermentation, were produced clay, marle, ſandſtone, coal, iron, (with the baſes of variety of acids;) all which were ſtratified by their having been formed at different, and very diſtant periods of time.

8. In the elevation of the mountains very numerous and deep fiſſures neceſſarily were produced. In theſe fiſſures many of the metals are formed partly from deſcending materials, and partly from aſcending ones raiſed in vapour by ſubterraneous fires. In the fiſſures of granite or porphery quartz is formed; in the fiſſures of limeſtone calcareous ſpar is produced.

9. During theſe firſt great volcanic fires it is probable the atmoſphere was either produced, or much increaſed; a proceſs which is perhaps now going on in the moon; Mr. Herſchell having diſcovered a volcanic crater three miles broad burning on her diſk.

10. The ſummits of the new mountains were cracked into innumerable lozenges by the cold dews or ſnows falling upon them when red hot. From theſe ſummits, which were then twice as high as at preſent, cubes and lozenges of granite, and baſalt, and quartz in ſome countries, and of marble and flints in others, deſcended gradually into the valleys, and were rolled together in the beds of rivers, (which were then ſo large as to occupy the whole valleys, which they now only interſect;) and produced the great beds of gravel, of which many valleys conſiſt.

11. In ſeveral parts of the earth's ſurface ſubſequent earthquakes, from the fermentation of moraſſes, have at different periods of time deranged the poſition of the matters above deſcribed. Hence the gravel, which was before in the beds of rivers, has in ſome places been raiſed into mountains, along with clay and coal ſtrata which were formed from moraſſes and waſhed down from eminences into the beds of rivers or the neighbouring ſeas, and in part raiſed again with gravel or marine ſhells over them; but this has only obtained in few places compared with the general diſtribution of ſuch materials. Hence there ſeem to have exiſted two ſources of earthquakes, which have occurred at great diſtance of time from each other; one from the granite beds in the central parts of the earth, and the other from the moraſſes on its ſurface. All the ſubſequent earthquakes and volcanos of modern days compared with theſe are of ſmall extent and inſignificant effect.

12. Beſides the argillaceous ſand-ſtone produced from moraſſes, which is ſtratified with clay, and coal, and iron, other great beds of ſiliceous ſand have been formed in the ſea by the combination of an unknown acid from moraſſes, and the calcareous matters of the ocean.

13. The warm waters which are found in many countries, are owing to ſteam ariſing from great depths through the fiſſures of limeſtone or lava, elevated by ſubterranean fires, and condenſed between the ſtrata of the hills over them; and not from any decompoſition of pyrites or mangañeſe near the ſurface of the earth.

14. The columns of baſaltes have been raiſed by the congelation or expanſion of granite beds in the act of cooling from their ſemi-vitreous fuſion.

## NOTE XXV——EVAPORATION.

*Aquatic nymphs! you lead with viewleſs march*
*The winged vapour up the aerial arch.*

CANTO III. l. 13.

1. THE atmoſphere will diſſolve a certain quantity of moiſture as a chemical menſtruum, even when it is much below the freezing point, as appears from the diminution of ice ſuſpended in froſty air, but a much greater quantity of water is evaporated and ſuſpended in the air by means of heat, which is perhaps the univerſal cauſe of fluidity, for water is known to boil with leſs heat in vacuo, which is a proof that it will evaporate faſter in vacuo, and that the air therefore rather hinders than promotes its evaporation in higher degrees of heat. The quick evaporation occaſioned in vacuo by a ſmall degree of heat is agreeably ſeen in what is termed a pulſe-glaſs, which conſiſts of an exhauſted tube of glaſs with a bulb at each end of it and with about two thirds of the cavity filled with alcohol, in which the ſpirit is inſtantly ſeen to boil by the heat of the finger-end applied on a bubble of ſteam in the lower bulb, and is condenſed again in the upper bulb by the leaſt conceivable comparative coldneſs.

2. Another circumſtance evincing that heat is the principal cauſe of evaporation is that at the time of water being converted into ſteam, a great quantity of heat is taken away from the neighbouring bodies. If a thermometer be repeatedly dipped in ether, or in rectified ſpirit of wine, and expoſed to a blaſt of air, to expedite the evaporation by perpetually removing the ſaturated air from it, the thermometer will preſently ſink below freezing. This warmth, taken from the ambient bodies at the time of evaporation by the ſteam, is again given out when the ſteam is condenſed into water. Hence the water in a worm-tub during diſtillation ſo ſoon becomes hot; and hence the warmth accompanying the deſcent of rain in cold weather.

3. The third circumſtance, ſhewing that heat is the principal cauſe of evaporation, is, that ſome of the ſteam becomes again condenſed when

any part of the heat is withdrawn. Thus when warmer ſouth-weſt winds replete with moiſture ſucceed the colder north-eaſt winds, all bodies that are denſe and ſubſtantial, as ſtone walls, brick floors, &c. abſorb ſome of the heat from the paſſing air, and its moiſture becomes precipitated on them, while the north-eaſt winds become warmer on their arrival in this latitude, and are thence diſpoſed to take up more moiſture, and are termed drying winds.

4. Heat ſeems to be the principal cauſe of the ſolution of many other bodies, as common ſalt, or blue vitriol diſſolved in water, which when expoſed to ſevere cold are precipitated, or carried, to the part of the water laſt frozen; this I obſerved in a phial filled with a ſolution of blue vitriol which was frozen; the phial was burſt, the ice thawed, and a blue column of cupreous vitriol was left ſtanding upright on the bottom of the broken glaſs, as deſcribed in note XIX.

II. Hence water may either be diſſolved in air, and may then be called an aerial ſolution of water; or it may be diſſolved in the fluid matter of heat, according to the theory of M. Lavoiſier, and may then be called ſteam. In the former caſe it is probable there are many other vapours which may precipitate it, as marine acid gas, or fluor acid gas. So alcaline gas and acid gas diſſolved in air precipitate each other, nitrous gas precipitates vital air from its azote, and inflammable gas mixed with vital air ignited by an electric ſpark either produces or precipitates the water in both of them. Are there any ſubtle exhalations occaſionally diffuſed in the atmoſphere which may thus cauſe rain?

1. But as water is perhaps many hundred times more ſoluble in the fluid matter of heat than in air, I ſuppoſe the eduction of this heat, by whatever means it is occaſioned, is the principal cauſe of devaporation. Thus if a region of air is brought from a warmer climate, as the S. W. winds, it becomes cooled by its contact with the earth in this latitude, and parts with ſo much of its moiſture as was diſſolved in the quantity of calorique, or heat, which it now loſes, but retains that part which was ſuſpended by its attraction to the particles of air, or by aerial ſolution, even in the moſt ſevere froſts.

2. A ſecond immediate cauſe of rain is a ſtream of N. E. wind deſcending from a ſuperior current of air, and mixing with the warmer S. W. wind below; or the reverſe of this, viz. a ſuperior current of S. W. wind mixing with an inferior one of N. E. wind; in both theſe caſes the whole heaven becomes inſtantly clouded, and the moiſture contained in the S. W. current is precipitated. This cauſe of devaporation has been ingeniouſly explained by Dr. Hutton in the Tranſact. of Edinburgh,

Vol. I. and ſeems to ariſe from this circumſtance; the particles of air of the N. E. wind educe part of the heat from the S. W. wind, and therefore the water which was diſſolved by that quantity of *heat* is precipitated; all the other part of the water, which was ſuſpended by its attraction to the particles of air, or diſſolved in the remainder of the heat, continues unprecipitated.

3. A third method by which a region of air becomes cooled, and in conſequence depoſits much of its moiſture, is from the mechanical expanſion of air, when part of the preſſure is taken off. In this caſe the expanded air becomes capable of receiving or attracting more of the matter of heat into its interſtices, and the vapour, which was previouſly diſſolved in this heat, is depoſited, as is ſeen in the receiver of an air-pump, which becomes dewy, as the air within becomes expanded by the eduction of part of it. See note VII. Hence when the mercury in the barometer ſinks without a change of the wind the air generally becomes colder. See note VII. on Elementary Heat. And it is probably from the varying preſſure of the incumbent air that in ſummer days ſmall black clouds are often thus ſuddenly produced, and again ſoon vaniſh. See a paper in Philoſ. Tranſ. Vol. LXXVIII. intitled Frigorific Experiments on the Mechanical Expanſion of Air.

4. Another portion of atmoſpheric water may poſſibly be held in ſolution by the electric fluid, ſince in thunder ſtorms a precipitation of the water ſeems to be either the cauſe or the conſequence of the eduction of the electricity. But it appears more probable that the water is condenſed into clouds by the eduction of its heat, and that then the ſurplus of electricity prevents their coaleſcence into larger drops, which immediately ſucceeds the departure of the lightning.

5. The immediate cauſe why the barometer ſinks before rain is, firſt, becauſe a region of warm air, brought to us in the place of the cold air which it had diſplaced, muſt weigh lighter, both ſpecifically and abſolutely, if the height of the warm atmoſphere be ſuppoſed to be equal to that of the preceding cold one. And ſecondly, after the drops of rain begin to fall in any column of air, that column becomes lighter, the falling drops only adding to the preſſure of the air in proportion to the reſiſtance which they meet with in paſſing through that fluid.

If we could ſuppoſe water to be diſſolved in air without heat, or in very low degrees of heat, I ſuppoſe the air would become heavier, as happens in many chemical ſolutions, but if water diſſolved in the matter of heat, or calorique, be mixed with an aerial ſolution of water, there can be no doubt but an atmoſphere conſiſting of ſuch a mixture muſt become lighter in proportion to the quantity of calorique. On the ſame circumſtance depends the viſible vapour produced from the breath of animals in cold weather, or from a boiling kettle; the particles of cold air, with which it is mixed, ſteal a part of its heat, and become themſelves raiſed in temperature, whence part of the water is precipitated in viſible vapour, which, if in great quantity, ſinks to the ground; if in ſmall quantity, and the ſurrounding air is not previouſly ſaturated, it ſpreads itſelf till it becomes again diſſolved.

## NOTE XXVI.—SPRINGS.

*Your lucid bands condenſe with fingers chill*
*The blue miſt hovering round the gelid hill.*

CANTO III. l. 19.

THE ſurface of the earth conſiſts of ſtrata many of which were formed originally beneath the ſea, the mountains were afterwards forced up by ſubterraneous fires, as appears from the fiſſures in the rocks of which they conſiſt, the quantity of volcanic productions all over the world, and the numerous remains of craters of volcanos in mountainous countries. Hence the ſtrata which compoſe the ſides of mountains lie ſlanting downwards, and one or two or more of the external ſtrata not reaching to the ſummit when the mountain was raiſed up, the ſecond or third ſtratum or a more inferior one is there expoſed to day; this may be well repreſented by forceably thruſting a blunt inſtrument through ſeveral ſheets of paper, a bur will ſtand up with the lowermoſt ſheet ſtanding higheſt in the center of it. On this uppermoſt ſtratum, which is colder as it is more elevated, the dews are condenſed in large quantities; and ſliding down paſs under the firſt or ſecond or third ſtratum which compoſe the ſides of the hill; and either form a moraſs below, or a weeping rock, by oozing out in numerous places, or many of theſe leſs currents meeting together burſt out in a more copious rill.

The ſummits of mountains are much colder than the plains in their vicinity, owing to ſeveral cauſes; 1. Their being in a manner inſulated or cut off from the common heat of the earth, which is always of 48 degrees, and perpetually counteracts the effects of external cold beneath that degree. 2. From their ſurfaces being larger in proportion to their ſolid contents, and hence their heat more expeditiouſly carried away by the ever-moving atmoſphere. 3. The increaſing rarity of the air as the mountain riſes. All thoſe bodies which conduct electricity well or ill, conduct the matter of heat likewiſe well or ill. See note VII. Atmoſpheric air is a bad conductor of electricity and thence confines it on the body where it is accumulated, but when it is made very rare, as in the exhauſted receiver, the electric aura paſſes away immediately to any diſtance. The ſame circumſtance probably happens in reſpect to heat, which is thus kept by the denſer air on the plains from eſcaping, but is diſſipated on the hills where the air is thinner. 4. As the currents of air riſe up the ſides of mountains they become mechanically rarefied, the preſſure of the incumbent column leſſening as they aſcend. Hence the expanding air abſorbs heat from the mountains as it aſcends, as explained in note VII. 5. There is another, and perhaps more powerful cauſe, I ſuſpect, which may occaſion the great cold on mountains, and in the higher parts of the atmoſphere, and which has not yet been attended to; I mean that the fluid matter of heat may probably gravitate round the earth, and form an atmoſphere on its ſurface, mixed with the aerial atmoſphere, which may diminiſh or become rarer, as it recedes from the earth's ſurface, in a greater proportion than the air diminiſhes.

6. The great condenſation of moiſture on the ſummits of hills has another cauſe, which is the daſhing of moving clouds againſt them, in miſty days this is often ſeen to have great effect on plains, where an eminent tree by obſtructing the miſt as it moves along ſhall have a much greater quantity of moiſture drop from its leaves than falls at the ſame time on the ground in its vicinity. Mr. White, in his Hiſtory of Selborne gives an account of a large tree ſo ſituated, from which a ſtream flowed during a moving miſt ſo as to fill the cart-ruts in a lane otherwiſe not very moiſt, and ingeniouſly adds, that trees planted about ponds of ſtagnant water contribute much by theſe means to ſupply the reſervoir. The ſpherules which conſtitute a miſt or cloud are kept from uniting by ſo ſmall a power that a little agitation againſt the leaves of a tree, or the greater attraction of a flat moiſt ſurface, condenſes or precipitates them.

If a leaf has its ſurface moiſtened and particles of water ſeparate from each other as in a miſt be brought near the moiſtened ſurface of a leaf, each particle will be attracted more by that plain ſurface of water on the leaf than it can be by the ſurrounding particles of the miſt, becauſe globules only attract each other in one point, whereas a plain attracts a globule by a greater extent of its ſurface.

The common cold ſprings are thus formed on elevated grounds by the condenſed vapours, and hence are ſtronger when the nights are cold after hot days in ſpring, than even in the wet days of winter. For the warm atmoſphere during the day has diſſolved much more water than it can ſupport in ſolution during the cold of the night, which is thus depoſited in large quantities on the hills, and yet ſo gradually as to ſoak in between the ſtrata of them, rather than to ſlide off over their ſurfaces like ſhowers of rain. The common heat of the internal parts of the earth is aſcertained by ſprings which ariſe from ſtrata of earth too deep to be affected by the heat of ſummer or the froſts of winter. Thoſe in this country are of 48 degrees of heat, thoſe about Philadelphia were ſaid by Dr. Franklin to be 52; whether this variation is to be accounted for by the difference of the ſun's heat on that country, according to the ingenious theory of Mr. Kirwan, or to the vicinity of ſubterranean fires is not yet, I think, decided. There are however ſubterraneous ſtreams of water not exactly produced in this manner, as ſtreams iſſuing from ſiſſures in the earth, communicating with the craters of old volcanoes; in the Peak of Derbyſhire are many hollows, called ſwallows, where the land floods ſink into the earth, and come out at ſome miles diſtant, as at Ilam near Aſhborne. See note on Fica, Vol. II.

Other ſtreams of cold water ariſe from beneath the ſnow on the Alps and Andes, and other high mountains, which is perpetually thawing at its under ſurface by the common heat of the earth, and gives riſe to large rivers. For the origin of warm ſprings ſee note on Fucus, Vol. II.

# NOTE XXVII.——SHELL FISH.

*You round Echinus ray his arrowy mail,*
*Give the keel'd Nautilus his oar and ſail.*
*Firm to his rock with ſilver cords ſuſpend*
*The anchor'd Pinna, and his Cancer-friend.*

CANTO III. l. 67.

THE armour of the Echinus, or Sea-hedge Hog, conſiſts generally of moveable ſpines; (*Linnei Syſtem. Nat.* Vol. I. p. 1102.) and in that reſpect reſembles the armour of the land animal of the ſame name. The irregular protuberances on other ſea-ſhells, as on ſome ſpecies of the Purpura, and Murex, ſerve them as a fortification againſt the attacks of their enemies.

It is ſaid that this animal foreſees tempeſtuous weather, and ſinking to the bottom of the ſea adheres firmly to ſea-plants, or other bodies by means of a ſubſtance which reſembles the horns of ſnails. Above twelve hundred of theſe fillets have been counted by which this animal fixes itſelf; and when afloat, it contracts theſe fillets between the baſes of its points, the number of which often amounts to two thouſand. Dict. Raiſonne. art. Ourſin. de mer.

There is a kind of Nautilus, called by Linneus, Argonauta, whoſe ſhell has but one cell; of this animal Pliny affirms, that having exonerated its ſhell by throwing out the water, it ſwims upon the ſurface, extending a web of wonderful tenuity, and bending back two of its arms and rowing with the reſt, makes a ſail, and at length receiving the water dives again. Plin. IX. 29. Linneus adds to his deſcription of this animal, that like the Crab Diogenes or Bernhard, it occupies a houſe not its own, as it is not connected to its ſhell, and is therefore foreign to it; who could have given credit to this if it had not been atteſted by ſo many who have with their own eyes ſeen this argonaut in the act of ſailing? Syſt. Nat. p. 1161.

The Nautilus, properly ſo named by Linneus, has a ſhell conſiſting of many chambers, of which cups are made in the Eaſt with beautiful painting and carving on the mother-pearl. The animal is ſaid to inhabit only the uppermoſt or open chamber, which is larger than the reſt; and that the reſt remain empty except that the pipe, or ſiphunculus, which communicates from one to the other of them is filled with an appendage of the animal like a gut or ſtring. Mr. Hook in his Philoſ. Exper. p. 306, imagines this to be a dilatable or compreſſible tube, like the air-bladders of fiſh, and that by contracting or permitting it to expand, it renders its ſhell buoyant or the contrary. See Note on Ulva, Vol. II.

The Pinna, or Sea-wing, is contained in a two-valve ſhell, weighing ſometimes fifteen pounds, and emits a beard of fine long gloſſy ſilk-like fibres, by which it is ſuſpended to the rocks twenty or thirty feet beneath the ſurface of the ſea. In this ſituation it is ſo ſucceſsfully attacked by the eight-footed Polypus, that the ſpecies perhaps could not exiſt but for the exertions of the Cancer Pinnotheris, who lives in the ſame ſhell as a guard and companion. Amœn. Academ. Vol. II. p. 48. Lin. Syſt. Nat. Vol. I. p. 1159, and p. 1040.

The Pinnotheris, or Pinnophylax, is a ſmall crab naked like Bernard the Hermit, but is furniſhed with good eyes, and lives in the ſame ſhell with the Pinna; when they want food the Pinna opens its ſhell, and ſends its faithful ally to forage; but if the Cancer ſees the Polypus, he returns ſuddenly to the arms of his blind hoſteſs, who by cloſing the ſhell avoids the fury of her enemy; otherwiſe, when it has procured a booty, it brings it to the opening of the ſhell, where it is admitted, and they divide the prey. This was obſerved by Haſlequiſt in his voyage to Paleſtine.

The Byſſus of the antients, according to Ariſtotle, was the beard of the Pinna above mentioned, but ſeems to have been uſed by other writers indiſcriminately for any ſpun material, which was eſteemed finer or more valuable than wool. Reaumur ſays the threads of this Byſſus are not leſs fine or leſs beautiful than the ſilk, as it is ſpun by the ſilk-worm; the Pinna on the coaſts of Italy and Provence (where it is fiſhed up by iron-hooks fixed on long poles) is called the ſilk-worm of the ſea. The ſtockings and gloves manufactured from it, are of exquiſite fineneſs, but too warm for common wear, and are thence eſteemed uſeful in rheumatiſm and gout. Dict. raiſonné art. Pinne-marine. The warmth of the Byſſus, like that of ſilk, is probably owing to their being bad conductors of heat, as well as of electricity. When theſe fibres are broken by violence, this animal as well as the muſcle has the power to reproduce them like the common ſpiders, as was obſerved by M. Adanſon. As raw ſilk, and raw cobwebs, when ſwallowed, are liable to produce great ſickneſs (as I am informed) it is probable the part of muſcles, which ſometimes diſagrees with the people who eat them, may be this ſilky web, by which they attach themſelves to ſtones. The large kind of Pinna contains ſome mother-pearl of a reddiſh tinge, according to M. d'Argenville. The ſubſtance ſold under the name of Indian weed, and uſed at the bottom of fiſh-lines, is probably a production of this kind;

which however is ſcarcely to be diſtinguiſhed by the eye from the tendons of a rat's tail, after they have been ſeparated by putrefaction in water, and well cleaned and rubbed; a production, which I was once ſhewn as a great curioſity; it had the uppermoſt bone of the tail adhering to it, and was ſaid to have been uſed as an ornament in a lady's hair.

## NOTE XXVIII.—STURGEON.

*With worm-like beard his toothleſs lips array,*
*And teach the unweildy Sturgeon to betray.*

CANTO III. l. 71.

THE Sturgeon, *Acipenſer, Strurio.* Lin. Syſt. Nat. Vol. I. p. 403. is a fiſh of great curioſity as well as of great importance; his mouth is placed under the head, without teeth, like the opening of a purſe, which he has the power to puſh ſuddenly out or retract. Before this mouth under the beak or noſe hang four tendrils ſome inches long, and which ſo reſemble earth-worms that at firſt ſight they may be miſtaken for them. This clumſy toothleſs fiſh is ſuppoſed by this contrivance to keep himſelf in good condition, the ſolidity of his fleſh evidently ſhewing him to be a fiſh of prey. He is ſaid to hide his large body amongſt the weeds near the ſea-coaſt, or at the mouths of large rivers, only expoſing his cirrhi or tendrils, which ſmall fiſh or ſea-inſects miſtaking for real worms approach for plunder, and are ſucked into the jaws of their enemy. He has been ſuppoſed by ſome to root into the ſoil at the bottom of the ſea or rivers; but the cirrhi, or tendrils abovementioned, which hang from his ſnout over his mouth, muſt themſelves be very inconvenient for this purpoſe, and as it has no jaws it evidently lives by ſuction, and during its reſidence in the ſea a quantity of ſea-inſects are found in its ſtomach.

The fleſh was ſo valued in the time of the Emperor Severus, that it was brought to table by ſervants with coronets on their heads, and preceded by muſic, which might give riſe to its being in our country preſented by the Lord Mayor to the King. At preſent it is caught in the Danube, and the Walga, the Don, and other large rivers for various purpoſes. The ſkin makes the beſt covering for carriages; iſinglaſs is prepared from parts of the ſkin; cavear from the ſpawn; and the fleſh is pickled or ſalted, and ſent all over Europe.

## NOTE XXIX.—OIL ON WATER.

*Who with fine films, ſuſpended o'er the deep,*
*Of Oil effuſive lull the waves to ſleep.*

Canto III. l. 87.

THERE is reaſon to believe that when oil is poured upon water, the two ſurfaces do not touch each other, but that oil is ſuſpended over the water by their mutual repulſion. This ſeems to be rendered probable by the following experiment: if one drop of oil be dropped on a baſon of water, it will immediately diffuſe itſelf over the whole, for there being no friction between the two ſurfaces, there is nothing to prevent its ſpreading itſelf by the gravity of the upper part of it, except its own tenacity, into a pellicle of the greateſt tenuity. But if a ſecond drop of oil be put upon the former, it does not ſpread itſelf, but remains in the form of a drop, as the other already occupied the whole ſurface of the baſon, and there is friction in oil paſſing over oil, though none in oil paſſing over water.

Hence when oil is diffuſed on the ſurface of water gentle breezes have no influence in raiſing waves upon it; for a ſmall quantity of oil will cover a very great ſurface of water, (I ſuppoſe a ſpoonful will diffuſe itſelf over ſome acres) and the wind blowing upon this carries it gradually forwards; and there being no friction between the two ſurfaces the water is not affected. On which account oil has no effect in ſtilling the agitation of the water after the wind ceaſes, as was found by the experiments of Dr. Franklin.

This circumſtance lately brought into notice by Dr. Franklin had been mentioned by Pliny, and is ſaid to be in uſe by the divers for pearls, who in windy weather take down with them a little oil in their mouths, which they occaſionally give out when the inequality of the ſupernatant waves prevents them from ſeeing ſufficiently diſtinctly for their purpoſe.

The wonderful tenuity with which oil can be ſpread upon water is evinced by a few drops projected from a bridge, where the eye is properly placed over it, paſſing through all the priſmatic colours as it diffuſes itſelf. And alſo from another curious experiment of Dr. Franklin's: he cut a piece of cork to about the ſize of a letter-wafer, leaving a point ſtanding off like a tangent at one edge of the circle. This piece of cork was then dipped in oil and thrown into a large pond of water, and as the oil flowed off at the point, the cork-wafer continued to revolve in a contrary direction for ſeveral minutes. The oil flowing off all that time at the pointed tangent in coloured ſtreams. In a ſmall pond of water this experiment does not ſo well ſucceed, as the circulation of the cork ſtops as ſoon as the water becomes covered with the pellicle of oil. See Additional Note, No. XIII. and Note on Fucus, Vol. II.

The eaſe with which oil and water ſlide over each other is agreeably ſeen if a phial be about half filled with equal parts of oil and water, and made to oſcillate ſuſpended by a ſtring, the upper ſurface of the oil and the lower one of the water will always keep ſmooth; but the agitation of the ſurfaces where the oil and water meet, is curious; for their ſpecific gravities being not very different, and their friction on each other nothing, the higheſt ſide of the water, as the phial deſcends in its oſcillation, having acquired a greater momentum than the loweſt ſide (from its having deſcended further) would riſe the higheſt on the aſcending ſide of the oſcillation, and thence puſhes the then uppermoſt part of the water amongſt the oil.

## NOTE XXX.—SHIP-WORM.

*Meet fell Teredo, as he mines the keel*
*With beaked head, and break his lips of ſteel.*

CANTO III. l. 91.

THE Teredo, or ſhip-worm, has two calcareous jaws, hemiſpherical, flat before, and angular behind. The ſhell is taper, winding, penetrating ſhips and ſubmarine wood, and was brought from India into Europe, Linnei Syſtem. Nat. p. 1267. The Tarieres, or ſea-worms, attack and erode ſhips with ſuch fury, and in ſuch numbers, as often greatly to en-danger them. It is ſaid that our veſſels have not known this new enemy above fifty years, that they were brought from the ſea about the Antilles to our parts of the ocean, where they have increaſed prodigiouſly. They bore their paſſage in the direction of the fibres of the wood, which is their nouriſhment, and cannot return or paſs obliquely, and thence when they come to a knot in the wood, or when two of them meet together with their ſtony mouths, they periſh for want of food.

In the years 1731 and 1732 the United Provinces were under a dreadful alarm concerning theſe inſects, which had made great depredation on the piles which ſupport the banks of Zeland, but it was happily diſcovered a few years afterwards that theſe inſects had totally abandoned that iſland, (Dict. Raiſonné, art. Vers Rongeurs,) which might have been occaſioned by their not being able to live in that latitude when the winter was rather ſeverer than uſual.

## NOTE XXXI.—MAELSTROM.

*Turn the broad helm, the fluttering canvas urge*
*From Maelſtrom's fierce innavigable ſurge.*

CANTO III. l. 93.

ON the coaſt of Norway there is an extenſive vortex, or eddy, which lies between the iſlands of Moſkoe and Moſkenas, and is called Moſkoeſtrom, or Maelſtrom; it occupies ſome leagues in circumference, and is ſaid to be very dangerous and often deſtructive to veſſels navigating theſe ſeas. It is not eaſy to underſtand the exiſtence of a conſtant deſcending ſtream without ſuppoſing it muſt paſs through a ſubterranean cavity to ſome other part of the earth or ocean which may lie beneath its level; as the Mediterranean ſeems to lie beneath the level of the Atlantic ocean, which therefore conſtantly flows into it through the Straits; and the waters of the Gulph of Mexico lie much above the level of the ſea about the Floridas and further northward, which gives riſe to the Gulph-ſtream, as deſcribed in note on Caſſia in Vol. II.

The Maelſtrom is ſaid to be ſtill twice in about twenty-four hours when the tide is up, and moſt violent at the oppoſite times of the day. This is not difficult to account for, ſince when ſo much water is brought over the ſubterraneous paſſage, if ſuch exiſts, as compleatly to fill it and ſtand many feet above it, leſs diſturbance muſt appear on the ſurface. The Maelſtrom is deſcribed in the Memoires of the Swediſh Academy of Sciences, and Pontoppiden's Hiſt. of Norway, and in Univerſal Muſeum for 1763, p. 131.

The reaſon why eddies of water become hollow in the middle is becauſe the water immediately over the centre of the well, or cavity, falls faſter, having leſs friction to oppoſe its deſcent, than the water over the circumference or edges of the well. The circular motion or gyration of eddies depends on the obliquity of the courſe of the ſtream, or to the friction or oppoſition to it being greater on one ſide of the well than the other; I have obſerved in water paſſing through a hole in the bottom of a trough, which was always kept full, the gyration of the ſtream might be turned either way by increaſing the oppoſition of one ſide of the eddy with one's finger, or by turning the ſpout, through which the water was introduced, a little more obliquely to the hole on one ſide or on the other. Lighter bodies are liable to be retained long in eddies of water, while thoſe rather heavier than water are ſoon thrown out beyond the circumference by their acquired momentum becoming greater than that of the water. Thus if equal portions of oil and water be put into a phial, and by means of a ſtring be whirled in a circle round the hand, the water will always keep at the greater diſtance from the centre, whence in the eddies formed in rivers during a flood a perſon who endeavours to keep above water or to ſwim is liable to be detained in them, but on ſuffering himſelf to ſink or dive he is ſaid readily to eſcape. This circulation of water in deſcending through a hole in a veſſel Dr. Franklin has ingeniouſly applied to the explanation of hurricanes or eddies of air.

## NOTE XXXII.——GLACIERS.

*While round dark crags impriſon'd waters bend*
*Through rifted ice, in ivory veins deſcend.*

CANTO III. l. 113.

THE common heat of the interior parts of the earth being always 48 degrees, both in winter and ſummer, the ſnow which lies in contact with it is always in a thawing ſtate; Hence in ice-houſes the external parts of the collection of ice is perpetually thawing and thus preſerves the internal part of it; ſo that it is neceſſary to lay up many tons for the preſervation of one ton. Hence in Italy conſiderable rivers have their ſource from beneath the eternal glaciers, or mountains of ſnow and ice.

In our country when the air in the courſe of a froſt continues a day or two at very near 32 degrees, the common heat of the earth thaws the ice on its ſurface, while the thermometer remains at the freezing point. This circumſtance is often obſervable in the rimy mornings of ſpring; the thermometer ſhall continue at the freezing point, yet all the rime will vaniſh, except that which happens to lie on a bridge, a board, or on a cake of cow-dung; which being thus as it were inſulated or cut off from ſo free a communication with the common heat of the earth by means of the air under the bridge, or wood, or dung, which are bad conductors of heat, continues ſome time longer unthawed. Hence when the ground is covered thick with ſnow, though the froſt continues, and the ſun does not ſhine, yet the ſnow is obſerved to decreaſe very ſenſibly. For the common heat of the earth melts the under ſurface of it, and the upper one evaporates by its ſolution in the air. The great evaporation of ice was obſerved by Mr. Boyle, which experiment I repeated ſome time ago. Having ſuſpended a piece of ice by a wire and weighed it with care without touching it with my hand, I hung it out the whole of a clear froſty night, and found in the morning it had loſt nearly a fifth of its weight. Mr. N. Wallerius has ſince obſerved that ice at the time of its congelation evaporates faſter than water in its fluid form; which may be accounted for from the heat given out at the inſtant of freezing; (Sauſſure's Eſſais ſur Hygromet. p. 249.) but this effect is only momentary.

Thus the vegetables that are covered with ſnow are ſeldom injured; ſince, as they lie between the thawing ſnow, which has 32 degrees of heat, and the covered earth which has 48, they are preſerved in a degree of heat between theſe; viz. in 40 degrees of heat. Whence the moſs on which the rein-deer feed in the northern latitudes vegetates beneath the ſnow; (See note on Muſchus, Vol. II.) and hence many Lapland and Alpine plants periſhed through cold in the botanic garden at Upſal, for in their native ſituations, though the cold is much more intenſe, yet at its very commencement they are covered deep with ſnow, which remains till late in the ſpring. For this fact ſee Amænit Academ. Vol. I. No. 48. In our climate ſuch plants do well covered with dried fern, under which they will grow, and even flower, till the ſevere vernal froſts ceaſe. For the increaſe of glaciers ſee Note on Canto I. l. 529.

## NOTE XXXIII.——WINDS.

*While ſouthern gales o'er weſtern oceans roll,*
*And Eurus ſteals his ice-winds from the pole.*

CANTO IV. l. 15.

THE theory of the winds is yet very imperfect, in part perhaps owing to the want of obſervations ſufficiently numerous of the exact times and places where they begin and ceaſe to blow, but chiefly to our yet imperfect knowledge of the means by which great regions of air are either ſuddenly produced or ſuddenly deſtroyed.

The air is perpetually ſubject to increaſe or diminution from its combination with other bodies, or its evolution from them. The vital part of the air, called oxygene, is continually produced in this climate from the perſpiration of vegetables in the ſunſhine, and probably from the action of light on clouds or on water in the tropical climates, where the ſun has greater power, and may exert ſome yet-unknown laws of luminous combination. Another part of the atmoſphere, which is called azote, is perpetually ſet at liberty from animal and vegetable bodies by putrefaction or combuſtion, from many ſprings of water, from volatile alcali, and probably from fixed alcali, of which there is an exhauſtleſs ſource in the water of the ocean. Both theſe component parts of the air are perpetually again diminiſhed by their contact with the ſoil, which covers the ſurface of the earth, producing nitre. The oxygene is diminiſhed in the production of all acids, of which the carbonic and muriatic exiſt in great abundance. The azote is diminiſhed in the growth of animal bodies, of which it conſtitutes an important part, and in its combinations with many other natural productions.

They are both probably diminiſhed in immenſe quantities by uniting with the inflammable air, which ariſes from the mud of rivers and lakes at ſome ſeaſons, when the atmoſphere is light: the oxygene of the air producing water, and the azote producing volatile alcali by their combinations with this inflammable air. At other ſeaſons of the year theſe principles may again change their combinations, and the atmoſpheric air be reproduced.

Mr. Lavoiſier found that one pound of charcoal in burning conſumed two pounds nine ounces of vital air, or oxygene. The conſumption of vital air in the proceſs of making red lead may readily be reduced to calculation; a ſmall barrel contains about twelve hundred weight of this commodity, 1200 pounds of lead by calcination abſorb about 144 pounds of vital air; now as a cubic foot of water weighs 1000 averdupois ounces, and as vital air is above 800 times lighter than water, it follows that every barrel of red lead contains nearly 2000 cubic feet of vital air. If this can be performed in miniature in a ſmall oven, what may not be done in the immenſe elaboratories of nature!

Theſe great claboratories of nature include almoſt all her foſſil as well as her animal and vegetable productions. Dr. Prieſtley obtained air of greater or leſs purity, both vital and azotic, from almoſt all the foſſil ſubſtances he ſubjected to experiment. Four ounce-weight of lava from Iceland heated in an earthen retort yielded twenty ounce-meaſures of air.

| | | | |
|---|---|---|---|
| 4 | ounce-weight of lava | gave | 20 ounce meaſures of air. |
| 7 | baſaltes | | 104 |
| 2 | toadſtone | | 40 |
| 1½ | granite | | 20 |
| 1 | elvain | | 30 |
| 7 | gypſum | | 230 |
| 4 | blue ſlate | | 230 |
| 4 | clay | | 20 |
| 4 | limeſtone-ſpar | | 830 |

| | | | | |
|---|---|---|---|---|
| 5 | ounce weight of limeſtone | gave | 1160 | ounce meaſures of air |
| 3 | …… chalk | …… | 630 | …… |
| 3½ | …… white iron-ore | …… | 560 | …… |
| 4 | …… dark iron-ore | …… | 410 | …… |
| ½ | …… molybdena | …… | 25 | …… |
| ¼ | …… ſtream tin | …… | 20 | …… |
| 2 | …… ſteatites | …… | 40 | …… |
| 2 | …… barytes | …… | 26 | …… |
| 2 | …… black wad | …… | 80 | …… |
| 4 | …… ſand ſtone | …… | 75 | …… |
| 3 | …… coal | …… | 700 | …… |

In this account the fixed air was previouſly extracted from the limeſtones by acids, and the heat applied was much leſs than was neceſſary to extract all the air from the bodies employed. Add to this the known quantities of air which are combined with the calciform ores, as the ochres of iron, manganeſe, calamy, grey ore of lead, and ſome idea may be formed of the great production of air in volcanic eruptions, as mentioned in note on Chunda, Vol. II. and of the perpetual abſorptions and evolutions of whole oceans of air from every part of the earth.

But there would ſeem to be an officina aeris, a ſhop where air is both manufactured and deſtroyed in the greateſt abundance within the polar circles, as will hereafter be ſpoken of. Can this be effected by ſome yet unknown law of the congelation of aqueous or ſaline fluids, which may ſet at liberty their combined heat, and convert a part both of the acid and alcali of ſea-water into their component airs? Or on the contrary can the electricity of the northern lights convert inflammable air and oxygene into water, whilſt the great degree of cold at the poles unites the azote with ſome other baſe? Another officina aeris, or manufacture of air, would ſeem to exiſt within the tropics or at the line, though in a much leſs quantity than at the poles, owing perhaps to the action of the ſun's light on the moiſture ſuſpended in the air, as will alſo be ſpoken of hereafter; but in all other parts of the earth theſe abſorptions and evolutions of air in a greater or leſs degree are perpetually going on in inconceivable abundance; increaſed probably, and diminiſhed at different ſeaſons of the year by the approach or retroceſſion of the ſun's light; future diſcoveries muſt elucidate this part of the ſubject. To this ſhould be added, that as heat and electricity, and perhaps magnetiſm, are known to diſplace air, it is not impoſſible but that the increaſed or diminiſhed quantities of theſe fluids diffuſed in the atmoſphere may increaſe its weight as well as its bulk; ſince their ſpecific attractions or affinities to matter are very ſtrong, they probably alſo poſſeſs general gravitation to the earth; a ſubject which wants further inveſtigation. See Note XXVI.

## SOUTH-WEST WINDS.

The velocity of the ſurface of the earth in moving round its axis diminiſhes from the equator to the poles. Whence if a region of air in this country ſhould be ſuddenly removed a few degrees towards the north it muſt conſtitute a weſtern wind, becauſe from the velocity it had previouſly acquired in this climate by its friction with the earth it would for a time move quicker than the ſurface of the country it was removed to; the contrary muſt enſue when a region of air is tranſported from this country a few degrees ſouthward, becauſe the velocity it had acquired in this climate would be leſs than that of the earth's ſurface where it was removed to, whence it would appear to conſtiute a wind from the eaſt, while in reality the eminent parts of the earth would be carried againſt the too ſlow air. But if this tranſportation of air from ſouth to north be performed gradually, the motion of the wind will blow in the diagonal between ſouth and weſt. And on the contrary if a region of air be gradually removed from north to ſouth it would alſo blow diagonally between the north and eaſt, from whence we may ſafely conclude that all our winds in this country which blow from the north or eaſt, or any point between them, conſiſt of regions of air brought from the north; and that all our winds blowing from the ſouth or weſt, or from any point between them, are regions of air brought from the ſouth.

It frequently happens during the vernal months that after a north-eaſt wind has paſſed over us for ſeveral weeks, during which time the barometer has ſtood at above 30½ inches, it becomes ſuddenly ſucceeded by a ſouth-weſt wind, which alſo continues ſeveral weeks, and the barometer ſinks to nearly 28½ inches. Now as two inches of the mercury in the barometer balance one-fifteenth part of the whole atmoſphere, an important queſtion here preſents itſelf, *what is become of all this air?*

1. This great quantity of air can not be carried in a ſuperior current towards the line, while the inferior current flows towards the poles, becauſe then it would equally affect the barometer, which ſhould not therefore ſubſide from 30½ inches to 28½ for ſix weeks together.

2. It cannot be owing to the air having loſt all the moiſture which was previouſly diſſolved in it, becauſe theſe warm ſouth-weſt winds are replete with moiſture, and the cold north-eaſt winds, which weigh up the mercury in the barometer to 31 inches, conſiſt of dry air

3. It can not be carried over the polar regions and be accumulated on the meridian oppoſite to us in its paſſage towards the line, as ſuch an accumulation would equal one-fifteenth of the whole atmoſphere, and can not be ſuppoſed to remain in that ſituation for ſix weeks together.

4. It can not depend on the exiſtence of tides in the atmoſphere, ſince it muſt then correſpond to lunar periods. Nor to accumulations of air from the ſpecific levity of the upper regions of the atmoſphere, ſince its degree of fluidity muſt correſpond with its tenuity, and conſequently ſuch great mountains of air can not be ſuppoſed to exiſt for ſo many weeks together as the ſouth-weſt winds ſometimes continue.

5. It remains therefore that there muſt be at this time a great and ſudden abſorption of air in the polar circle by ſome unknown operation of nature, and that the ſouth wind runs in to ſupply the deficiency. Now as this ſouth wind conſiſts of air brought from a part of the earth's ſurface which moves faſter than it does in this climate, it muſt have at the ſame time a direction from the weſt by retaining part of the velocity it had previouſly acquired. Theſe ſouth-weſt winds coming from a warmer country, and becoming colder by their contact with the earth of this climate, and by their expanſion, (ſo great a part of the ſuperincumbent atmoſphere having vaniſhed,) precipitate their moiſture; and as they continue for ſeveral weeks to be abſorbed in the polar circle would ſeem to receive a perpetual ſupply from the tropical regions, eſpecially over the line, as will hereafter be ſpoken of.

It may ſometimes happen that a north-eaſt wind having paſſed over us may be bent down and driven back before it has acquired any heat from the climate, and may thus for a few hours or a day have a ſouth-weſt direction, and from its deſcending from a higher region of the atmoſphere may poſſeſs a greater degree of cold than an inferior north-eaſt current of air.

The extreme cold of Jan. 13, 1709, at Paris came on with a gentle ſouth wind, and was diminiſhed when the wind changed to the north, which is accounted for by Mr. Homberg from a reflux of air which had been flowing for ſome time from the north. Chemical Eſſays by R. Watſon, Vol. V. p. 182.

It may happen that a north-eaſt current may for a day or two paſs over us and produce inceſſant rain by mixing with the inferior ſouth-weſt current; but this as well as the former is of ſhort duration, as its friction will ſoon carry the inferior current along with it, and dry or froſty weather will then ſucceed.

## NORTH-EAST WINDS.

The north-eaſt winds of this country conſiſt of regions of air from the north, travelling ſometimes at the rate of about a mile in two minutes during the vernal months for ſeveral weeks together from the polar regions toward the ſouth, the mercury in the barometer ſtanding above 30. Theſe winds conſiſt of air greatly cooled by the evaporation of the ice and ſnow over which it paſſes, and as they become warmer by their contact with the earth of this climate are capable of diſſolving more moiſture as they paſs along, and are thence attended with froſts in winter and with dry hot weather in ſummer.

1. This great quantity of air can not be ſupplied by ſuperior currents paſſing in a contrary direction from ſouth to north, becauſe ſuch currents muſt as they ariſe into the atmoſphere a mile or two high become expoſed to ſo great cold as to occaſion them to depoſit their moiſture, which would fall through the inferior current upon the earth in ſome part of their paſſage.

2. The whole atmoſphere muſt have increaſed in quantity, becauſe it appears by the barometer that there exiſts one fifteenth part more air over us for many weeks together, which could not be thus accumulated by difference of temperature in reſpect to heat, or by any aeroſtatic laws at preſent known, or by any lunar influence.

From whence it would appear that immenſe maſſes of air were ſet at liberty from their combinations with ſolid bodies, along with a ſufficient quantity of combined heat, within the polar circle, or in ſome region to the north of us; and that they thus perpetually increaſe the quantity of the atmoſphere; and that this is again at certain times re-abſorbed, or enters into new combinations at the line or tropical regions. By which wonderful contrivance the atmoſphere is perpetually renewed and rendered fit for the ſupport of animal and vegetable life.

## SOUTH-EAST WINDS.

The ſouth-eaſt winds of this country conſiſt of air from the north which had paſſed by us, or over us, and before it had obtained the velocity of the earth's ſurface in this climate had been driven back, owing to a deficiency of air now commencing at the polar regions. Hence theſe are generally dry or freezing winds, and if they ſucceed north-eaſt winds ſhould prognoſticate a change of wind from north-eaſt to ſouth-weſt; the barometer is generally about 30. They are ſometimes attended with cloudy weather, or rain, owing to their having acquired an increaſed degree of warmth and moiſture before they became retrograde; or to their being mixed with air from the ſouth.

2. Sometimes theſe ſouth-eaſt winds conſiſt of a vertical eddy of north-eaſt air, without any mixture of ſouth-weſt air; in that caſe the barometer continues above 30, and the weather is dry or froſty for four or five days together.

It ſhould here be obſerved, that air being an elaſtic fluid muſt be more liable to eddies than water, and that theſe eddies muſt extend into cylinders or vortexes of greater diameter, and that if a vertical eddy of north-eaſt air be of ſmall diameter or has paſſed but a little way to the ſouth of us before its return, it will not have gained the velocity of the earth's ſurface to the ſouth of us, and will in conſequence become a ſouth-eaſt wind.—But if the vertical eddy be of large diameter, or has paſſed much to the ſouth of us, it will have acquired velocity from its friction with the earth's ſurface to the ſouth of us, and will in conſequence on its return become a ſouth-weſt wind, producing great cold.

## NORTH-WEST WINDS.

There ſeem to be three ſources of the north-weſt winds of this hemiſphere of the earth. 1. When a portion of ſouthern air, which was paſſing over us, is driven back by accumulation of new air in the polar regions. In this caſe I ſuppoſe they are generally moiſt or rainy winds, with the barometer under 30, and if the wind had previouſly been in the ſouth-weſt, it would ſeem to prognoſticate a change to the north-eaſt.

2. If a current of north wind is paſſing over us but a few miles high, without any eaſterly direction; and is bent down upon us, it muſt immediately poſſeſs a weſterly direction, becauſe it will now move faſter than the ſurface of the earth where it arrives; and thus becomes changed from a north-eaſt to a north-weſt wind. This deſcent of a north-eaſt current of air producing a north-weſt wind may continue ſome days with clear or freezing weather, as it may be ſimply owing to a vertical eddy of north-eaſt air, as will be ſpoken of below. It may otherwiſe be forced down by a current of ſouth-weſt wind paſſing over it, and in this caſe it will be attended with rain for a few days by the mixture of the two airs of different degrees of heat; and will prognoſticate a change of wind from north-eaſt to ſouth-weſt if the wind was previouſly in the north-eaſt quarter.

3. On the eaſtern coaſt of North America the north-weſt winds bring froſt, as the north-eaſt winds do in this country, as appears from variety of teſtimony. This ſeems to happen from a vertical ſpiral eddy made in the atmoſphere between the ſhore and the ridge of mountains which form the ſpine or back-bone of that continent. If a current of water runs along the hypothenuſe of a triangle an eddy will be made in the included angle, which will turn round like a water-wheel as the ſtream paſſes in contact with one edge of it. The ſame muſt happen when a ſheet of air flowing along from the north-eaſt riſes from the ſhore in a ſtraight line to the ſummit of the Apalachian mountains, a part of the ſtream of north-eaſt air will flow over the mountains, another part will revert and circulate ſpirally between the ſummit of the country and the eaſtern ſhore, continuing to move toward the ſouth; and thus be changed from a north-eaſt to a north-weſt wind.

This vertical ſpiral eddy having been in contact with the cold ſummits of theſe mountains, and deſcending from higher parts of the atmoſphere will loſe part of its heat, and thus conſtitute one cauſe of the greater coldneſs of the eaſtern ſides of North America than of the European ſhores oppoſite to them, which is ſaid to be equal to twelve degrees of north latitude, which is a wonderful fact, not otherwiſe eaſy to be explained, ſince the heat of the ſprings at Philadelphia is ſaid to be 52, which is greater than the medium heat of the earth in this country.

The exiſtence of vertical eddies, or great cylinders of air rolling on the ſurface of the earth, is agreeable to the obſervations of the conſtructors of windmills; who on this idea place the area of the ſails leaning backwards, inclined to the horizon; and believe that then they have greater power than when they are placed quite perpendicularly. The ſame kind of rolling cylinders of water obtain in rivers owing to the friction of the water againſt the earth at their bottoms; as is known by bodies having been obſerved to float upon their ſurfaces quicker than when immerſed to a certain depth. Theſe vertical eddies of air probably exiſt all over the earth's ſurface, but particularly at the bottom or ſides of mountains; and more ſo probably in the courſe of the ſouth-weſt than of the north-eaſt winds; becauſe the former fall from an eminence, as it were on a part of the earth where there is a deficiency of the quantity of air; as is ſhewn by the ſinking of the barometer: whereas the latter are puſhed or ſqueezed forward by an addition to the atmoſphere behind them, as appears by the riſing of the barometer.

## TRADE-WINDS.

A column of heated air becomes lighter than before, and will therefore aſcend, by the preſſure of the cold air which ſurrounds it, like a cork in water, or like heated ſmoke in a chimney.

Now as the ſun paſſes twice over the equator for once over either tropic, the equator has not time to become cool; and on this account it is in general hotter at the line than at the tropics; and therefore the air over the line, except in ſome few inſtances hereafter to be mentioned, continues to aſcend at all ſeaſons of the year, preſſed upwards by regions of air brought from the tropics.

This air thus brought from the tropics to the equator, would conſtitute a north wind on one ſide of the equator, and a ſouth wind on the other; but as the ſurface of the earth at the equator moves quicker than the ſurface of the earth at the tropics, it is evident that a region of air brought from either tropic to the equator, and which had previouſly only acquired the velocity of the earth's ſurface at the tropics, will now move too ſlow for the earth's ſurface at the equator, and will thence appear to move in a direction contrary to the motion of the earth. Hence the trade-winds, though they conſiſt of regions of air brought from the north on one ſide of the line, and from the ſouth on the other, will appear to have the diagonal direction of north-eaſt and ſouth-weſt winds.

Now it is commonly believed that there are ſuperior currents of air paſſing over theſe north-eaſt and ſouth-weſt currents in a contrary direction, and which deſcending near the tropics produce vertical whirlpools of air. An important queſtion here again preſents itſelf, *What becomes of the moiſture which this heated air ought to depoſit, as it cools in the upper regions of the atmoſphere in its journey to the tropics?* It has been ſhewn by Dr. Prieſtley and Mr. Injenhouz that the green matter at the bottom of ciſterns, and the freſh leaves of plants immerſed in water, give out conſiderable quantities of vital air in the ſunſhine; that is, the perſpirable matter of plants (which is water much divided in its egreſs from their minute pores) becomes decompoſed by the ſun's light, and converted into two kinds of air, the vital and inflammable airs. The moiſture contained or diſſolved in the aſcending heated air at the line muſt exiſt in great tenuity; and by being expoſed to the great light of the ſun in that climate, the water may be decompoſed, and the new airs ſpread on the atmoſphere from the line to the poles.

1. From there being no conſtant depoſition of rains in the uſual courſe of the trade-winds, it would appear that the water riſing at the line is decompoſed in its aſcent.

2. From the obſervations of M. Bougner on the mountain Pinchinca, one of the Cordelieres immediately under the line, there appears to be no condenſible vapour above three or four miles high. Now though the atmoſphere at that height may be cold to a very conſiderable degree; yet its total deprivation of condenſible vapour would ſeem to ſhew, that its water was decompoſed; as there are no experiments to evince that any degree of cold hitherto known has been able to deprive air of its moiſture; and great abundance of ſnow is depoſited from the air that flows to the polar regions, though it is expoſed to no greater degrees of cold in its journey thither than probably exiſts at four miles height in the atmoſphere at the line.

3. The hygrometer of Mr. Sauſſure alſo pointed to dryneſs as he aſcended into rarer air; the ſingle hair of which it was conſtructed, contracting from deficiency of moiſture. Eſſais ſur l'Hygromet. p. 143.

From theſe obſervations it appears either that rare and cold air requires more moiſture to ſaturate it than denſe air; or that the moiſture becomes decompoſed and converted into air, as it aſcends into theſe cold and rare regions of the atmoſphere.

4. There ſeems ſome analogy between the circumſtance of air being produced or generated in the cold parts of the atmoſphere both at the line and at the poles.

## MONSOONS AND TORNADOES.

1. In the Arabian and Indian ſeas are winds, which blow ſix months one way, and ſix months the other, and are called Monſoons; by the accidental diſpoſitions of land and ſea it happens, that in ſome places the air near the tropic is ſuppoſed to become warmer when the ſun is vertical over it, than at the line. The air in theſe places conſequently aſcends preſſed upon one ſide by the north-eaſt regions of air, and on the other ſide by the ſouth-weſt regions of air. For as the air brought from the ſouth has previouſly obtained the velocity of the earth's ſurface at the line, it moves faſter than the earth's ſurface near the tropic where it now arrives, and beoomes a ſouth-weſt wind, while the air from the north becomes a north-eaſt wind as before explained. Theſe two winds do not ſo quietly join and aſcend as the north-eaſt and ſouth-eaſt winds, which

meet at the line with equal warmth and velocity and form the trade-winds; but as they meet in contrary directions before they aſcend, and cannot be ſuppoſed accurately to balance each other, a rotatory motion will be produced as they aſcend like water falling through a hole, and an horizontal or ſpiral eddy is the conſequence; theſe eddies are more or leſs rapid, and are called Tornadoes in their moſt violent ſtate, raiſing water from the ocean in the weſt or ſand from the deſerts of the eaſt, in leſs violent degrees they only mix together the two currents of north-eaſt and ſouth-weſt air, and produce by this means inceſſant rains, as the air of the north-eaſt acquires ſome of the heat from the ſouth-weſt wind, as explained in Note XXV. This circumſtance of the eddies produced by the monſoon-winds was ſeen by Mr. Bruce in Abyſſinia; he relates that for many ſucceſſive mornings at the commencement of the rainy monſoon, he obſerved a cloud of apparently ſmall dimenſions whirling round with great rapidity, and in a few minutes the heavens became covered with dark clouds with conſequent great rains. See Note on Canto III. l. 125.

2. But it is not only at the place where the air aſcends at the northern extremity of the rainy monſoon, and where it forms tornadoes, as obſerved above by Mr. Bruce, but over a great tract of country ſeveral degrees in length in certain parts as in the Arabian ſea, a perpetual rain for ſeveral months deſcends, ſimilar to what happens for weeks together in our own climate in a leſs degree during the ſouth-weſt winds. Another important queſtion preſents itſelf here, *If the climate to which this ſouth-weſt wind arrives, is not colder than that it comes from, why ſhould it depoſit its moiſture during its whole journey? if it be a colder climate, why does it come thither?* The tornadoes of air above deſcribed can extend but a little way, and it is not eaſy to conceive that a ſuperior cold current of air can mix with an inferior one, and thus produce ſhowers over ten degrees of country, ſince at about three miles high there is perpetual froſt; and what can induce theſe narrow and ſhallow currents to flow over each other ſo many hundred miles?

Though the earth at the northern extremity of this monſoon may be more heated by certain circumſtances of ſituation than at the line, yet it ſeems probable that the intermediate country between that and the line, may continue colder than the line (as in other parts of the earth) and hence that the air coming from the line to ſupply this aſcent or deſtruction of air at the northern extremity of the monſoon will be cooled all the way in its approach, and in conſequence depoſit its water. It ſeems probable that at the northern extremity of this monſoon, where the tornadoes or hurricanes

1. From there being no conſtant depoſition of rains in the uſual courſe of the trade-winds, it would appear that the water riſing at the line is decompoſed in its aſcent.

2. From the obſervations of M. Bougner on the mountain Pinchinca, one of the Cordelieres immediately under the line, there appears to be no condenſible vapour above three or four miles high. Now though the atmoſphere at that height may be cold to a very conſiderable degree; yet its total deprivation of condenſible vapour would ſeem to ſhew, that its water was decompoſed; as there are no experiments to evince that any degree of cold hitherto known has been able to deprive air of its moiſture; and great abundance of ſnow is depoſited from the air that flows to the polar regions, though it is expoſed to no greater degrees of cold in its journey thither than probably exiſts at four miles height in the atmoſphere at the line.

3. The hygrometer of Mr. Sauſſure alſo pointed to dryneſs as he aſcended into rarer air; the ſingle hair of which it was conſtructed, contracting from deficiency of moiſture. Eſſais ſur l'Hygromet. p. 143.

From theſe obſervations it appears either that rare and cold air requires more moiſture to ſaturate it than denſe air; or that the moiſture becomes decompoſed and converted into air, as it aſcends into theſe cold and rare regions of the atmoſphere.

4. There ſeems ſome analogy between the circumſtance of air being produced or generated in the cold parts of the atmoſphere both at the line and at the poles.

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As the ſouth-weſt winds are always attended with a light atmoſphere, an incipient vacancy, or a great diminution of air muſt have taken place to the northward of them in all parts of the earth wherever they exiſt, and a depoſition of their moiſture ſucceeds their being cooled by the climate they arrive at, and not by a contrary current of cold air over them, ſince in that caſe the barometer would not ſink. They may thus in our own country be termed monſoons without very regular periods.

3. Another cauſe of TORNADOES independent of the monſoons is ingeniouſly explained by Dr. Franklin; when in the tropical countries a ſtratum of inferior air becomes ſo heated by its contact with the warm earth, that its expanſion is increaſed more than is equivalent to the preſſure of the ſtratum of air over it; or when the ſuperior ſtratum becomes more condenſed by cold than the inferior one by preſſure, the upper region will deſcend and the lower one aſcend. In this ſituation if one part of the atmoſphere be hotter from ſome fortuitous circumſtances, or, has leſs preſſure over it, the lower ſtratum will begin to aſcend at this part, and reſemble water falling through a hole as mentioned above. If the lower region of air was going forwards with conſiderable velocity, it will gain an eddy by riſing up this hole in the incumbent heavy air, ſo that the whirlpool or tornado has not only its progreſſive velocity, but its circular one alſo, which thus lifts up or overturns every thing within its ſpiral whirl. By the weaker whirlwinds in this country the trees are ſometimes thrown down in a line of only twenty or forty yards in breadth, making a kind of avenue through a country. In the Weſt Indies the ſea riſes like a cone in the whirl, and is met by black clouds produced by the cold upper air and the warm lower air being rapidly mixed; whence are produced the great and ſudden rains called water-ſpouts; while the upper and lower airs exchange their plus or minus electricity in perpetual lightenings.

## LAND AND SEA-BREEZES.

The ſea being a tranſparent maſs is leſs heated at its ſurface by the ſun's rays than the land, and its continual change of ſurface contributes to preſerve a greater uniformity in the heat of the air which hangs over it. Hence the ſurface of the tropical iſlands is more heated during the day than the ſea that ſurrounds them, and cools more in the night by its greater elevation: whence in the afternoon when the lands of the tropical iſlands have been much heated by the ſun, the air over them aſcends preſſed upwards by the cooler air of the incircling ocean, in the morning again the land becoming cooled more than the ſea, the air over it deſcends by its increaſed gravity, and blows over the ocean near its ſhores.

## CONCLUSION.

1. There are various irregular winds beſides thoſe above deſcribed, which conſiſt of horizontal or vertical eddies of air owing to the inequality of the earth's ſurface, or the juxtapoſition of the ſea. Other irregular winds have their origin from increaſed evaporation of water, or its ſudden devaporation and deſcent in ſhowers; others from the partial expanſion and condenſation of air by heat and cold; by the accumulation or defect of electric fluid, or to the air's new production or abſorption occaſioned by local cauſes not yet diſcovered. See Notes VII. and XXV.

2. There ſeem to exiſt only two original winds: one conſiſting of air brought from the north, and the other of air brought from the ſouth. The former of theſe winds has alſo generally an apparent direction from the eaſt, and the latter from the weſt, ariſing from the different velocities of the earth's ſurface. All the other winds above deſcribed are deflections or retrogreſſions of ſome parts of theſe currents of air from the north or ſouth.

3. One fifteenth part of the atmoſphere is occaſionally deſtroyed, and occaſionally reproduced by unknown cauſes. Theſe cauſes are brought into immediate activity over a great part of the ſurface of the earth at nearly the ſame time, but always act more powerful to the northward than to the ſouthward of any given place; and would hence ſeem to have their principal effect in the polar circles, exiſting nevertheleſs though with leſs power toward the tropics or at the line.

For when the north-eaſt wind blows the barometer riſes, ſometimes from 28½ inches to 30½, which ſhews a great new generation of air in the north; and when the ſouth-weſt wind blows the barometer ſinks as much, which ſhews a great deſtruction of air in the north. But as the north-eaſt winds ſometimes continue for five or ſix weeks, the newly-generated air muſt be deſtroyed at thoſe times in the warmer climates to the ſouth of us, or circulate in ſuperior currents, which has been ſhewn to be improbable from its not depoſiting its water. And as the ſouth-weſt winds ſometimes continue for ſome weeks, there muſt be a generation of air to the ſouth at thoſe times, or ſuperior currents, which laſt has been ſhewn to be improbable.

4. The north-eaſt winds being generated about the poles are puſhed forwards towards the tropics or line, by the preſſure from behind, and hence they become warmer, as explained in Note VII. as well as by their coming into contact with a warmer part of the earth which contributes to make theſe winds greedily abſorb moiſture in their paſſage. On the contrary, the ſouth-weſt winds, as the atmoſphere is ſuddenly diminiſhed in the polar regions, are drawn as it were into an incipient vacancy, and become therefore expanded in their paſſage, and thus generate cold, as explained in Note VII. and are thus induced to part with their moiſture, as well as by their contact with a colder part of the earth's ſurface. Add to this, that the difference in the ſound of the north-eaſt and ſouth-weſt winds may depend on the former being puſhed forwards by a preſſure behind, and the latter falling as it were into a partial or incipient vacancy before; whence the former becomes more condenſed, and the latter more rarefied as it paſſes. There is a whiſtle, termed a lark-call, which conſiſts of a hollow cylinder of tin-plate, cloſed at each end, about half an inch in diameter and a quarter of an inch high, with oppoſite holes about the ſize of a gooſe-quill through the centre of each end; if this lark-whilſtle be held between the lips the ſound of it is manifeſtly different when the breath is forceably blown through it from within outwards, and when it is ſucked from without inwards. Perhaps this might be worthy the attention of organbuilders.

5. A ſtop is put to this new generation of air, when about a fifteenth of the whole is produced, by its increaſing preſſure; and a ſimilar boundary is fixed to its abſorption or deſtruction by the decreaſe of atmoſpheric preſſure. As water requires more heat to convert it into vapour under a heavy atmoſphere than under a light one, ſo in letting off the water from muddy fiſh-ponds great quantities of air-bubbles are ſeen to aſcend from the bottom, which were previouſly confined there by the preſſure of the water. Similar bubbles of inflammable air are ſeen to ariſe from lakes in many ſeaſons of the year, when the atmoſphere ſuddenly becomes light.

6. The increaſed abſorptions and evolutions of air muſt, like its ſimple expanſions, depend much on the preſence or abſence of heat and light, and will hence, in reſpect to the times and places of its production and deſtruction, be governed by the approach or retroceſſion of the ſun, and on the temperature, in regard to heat, of various latitudes, and parts of the ſame latitude, ſo well explained by Mr. Kirwan.

7. Though the immediate cauſe of the deſtruction or reproduction of great maſſes of air at certain times, when the wind changes from north to ſouth, or from ſouth to north can not yet be aſcertained; yet as there appears greater difficulty in accounting for this change of wind for any other known cauſes, we may ſtill ſuſpect that there exiſts in the arctic and antarctic circles a Bear or Dragon yet unknown to philoſophers, which at times ſuddenly drinks up, and as ſuddenly at other times vomits out one-fifteenth part of the atmoſphere: and hope that this or ſome future age will learn how to govern and domeſticate a monſter which might be rendered of ſuch important ſervice to mankind.

## INSTRUMENTS.

IF along with the uſual regiſters of the weather obſervations were made on the winds in many parts of the earth with the three following inſtruments, which might be conſtructed at no great expence, ſome uſeful information might be acquired.

1. To mark the hour when the wind changes from north-eaſt to ſouth-weſt, and the contrary. This might be managed by making a communication from the vane of a weathercock to a clock; in ſuch a manner, that if the vane ſhould revolve quite round, a tooth on its revolving axis ſhould ſtop the clock, or put back a ſmall bolt on the edge of a wheel revolving once in twenty-four hours.

2. To diſcover whether in a year more air paſſed from north to ſouth, or the contrary. This might be effected by placing a windmill-ſail of copper about nine inches diameter in a hollow cylinder about ſix inches long, open at both ends, and fixed on an eminent ſituation exactly north and ſouth. Thence only a part of the north-eaſt and ſouth-weſt currents would affect the ſail ſo as to turn it; and if its revolutions were counted by an adapted machinery, as the ſail would turn one way with the north currents of air, and the contrary one with the ſouth, the advance of the counting finger either way would ſhew which wind had prevailed moſt at the end of the year.

3. To diſcover the rolling cylinders of air, the vane of a weathercock might be ſo ſuſpended as to dip or riſe vertically, as well as to have its horizontal rotation.

# RECAPITULATION.

North-east winds conſiſt of air flowing from the north, where it ſeems to be occaſionally produced; has an apparent direction from the eaſt owing to its not having acquired in its journey the increaſing velocity of the earth's ſurface; theſe winds are analogous to the trade-winds between the tropics, and frequently continue in the vernal months for four and ſix weeks together, with a high barometer, and fair or froſty weather. 2. They ſometimes conſiſt of ſouth-weſt air, which had paſſed by us or over us, driven back by a new accumulation of air in the north. Theſe continue but a day or two, and are attended with rain. See Note XXV.

South-west wind conſiſts of air flowing from the ſouth, and ſeems occaſionally abſorbed at its arrival to the more northern latitudes. It has a real direction from the weſt owing to its not having loſt in its journey the greater velocity it had acquired from the earth's ſurface from whence it came. Theſe winds are analogous to the monſoons between the tropics, and frequently continue for four or ſix weeks together, with a low barometer and rainy weather. 2. They ſometimes conſiſt of north-eaſt air, which had paſſed by us or over us, which becomes retrograde by a commencing deficiency of air in the north. Theſe winds continue but a day or two, attended with ſeverer froſt with a ſinking barometer; their cold being increaſed by their expanſion, as they return, into an incipient vacancy.

North-west winds conſiſt, firſt, of ſouth-weſt winds, which have paſſed over us, bent down and driven back towards the ſouth by newly generated northern air. They continue but a day or two, and are attended with rain or clouds. 2. They conſiſt of north-eaſt winds bent down from the higher parts of the atmoſphere, and having there acquired a greater velocity than the earth's ſurface, are froſty or fair. 3. They conſiſt of north-eaſt winds formed into a vertical ſpiral eddy, as on the eaſtern coaſts of North America, and bring ſevere froſt.

South-east winds conſiſt, firſt, of north-eaſt winds become retrograde, continue for a day or two, froſty or fair, ſinking barometer. 2. They conſiſt of north-eaſt winds formed into a vertical eddy not a ſpiral one, froſt or fair.

North winds conſiſt, firſt, of air flowing ſlowly from the north, ſo that they acquire the velocity of the earth's ſurface as they approach, are fair or froſty, ſeldom occur. 2. They conſiſt of retrograde ſouth winds; theſe continue but a day or two, are preceded by ſouth-weſt winds; and are generally ſucceeded by north-eaſt winds, cloudy or rainy, barometer riſing.

SOUTH WINDS conſiſt, firſt, of air flowing ſlowly from the ſouth, loſing their previous weſtern velocity by the friction of the earth's ſurface as they approach, moiſt, ſeldom occur. 2. They conſiſt of retrograde north-winds; theſe continue but a day or two, are preceded by north-eaſt winds, and generally ſucceeded by ſouth-weſt winds, colder, barometer ſinking.

EAST WINDS conſiſt of air brought haſtily from the north, and not impelled farther ſouthward, owing to a ſudden beginning abſorption of air in the northern regions, very cold, barometer high, generally ſucceeded by ſouth-weſt wind.

WEST WINDS conſiſt of air brought haſtily from the ſouth, and checked from proceeding further to the north by a beginning production of air in the northern regions, warm and moiſt, generally ſucceeded by north-eaſt wind. 2. They conſiſt of air bent down from the higher regions of the atmoſphere, if this air be from the ſouth, and brought haſtily it becomes a wind of great velocity, moving perhaps 60 miles an hour, is warm and rainy; if it conſiſts of northern air bent down it is of leſs velocity and colder.

## *Application of the preceding Theory to ſome Extracts from a Journal of the Weather.*

*Dec.* 1, 1790. The barometer ſunk ſuddenly, and the wind, which had been ſome days north-eaſt with froſt, changed to ſouth-eaſt with an inceſſant though moderate fall of ſnow. A part of the northern air, which had paſſed by us I ſuppoſe, now became retrograde before it had acquired the velocity of the earth's ſurface to the ſouth of us, and being attended by ſome of the ſouthern air in its journey, the moiſture of the latter became condenſed and frozen by its mixture with the former.

*Dec.* 2, 3. The wind changed to north-weſt and thawed the ſnow. A part of the ſouthern air, which had paſſed by us or over us, with the retrograde northern air above deſcribed, was now in its turn driven back, before it had loſt the velocity of the ſurface of the earth to the ſouth of us, and conſequently became a north-weſt wind; and not having loſt the warmth it brought from the ſouth produced a thaw.

*Dec.* 4, 5. Wind changed to north-eaſt with froſt and a riſing barometer. The air from the north continuing to blow, after it had driven back the ſouthern air as above deſcribed, became a north-eaſt wind, having leſs velocity than the ſurface of the earth in this climate, and produced froſt from its coldneſs.

*Dec.* 6, 7. Wind now changed to the ſouth-weſt with inceſſant rain and a ſinking barometer. From unknown cauſes I ſuppoſe the quantity of air to be diminiſhed in the polar regions, and the ſouthern air cooled by the earth's ſurface, which was previouſly frozen, depoſits its moiſture for a day or two; afterwards the wind continued ſouth-weſt without rain, as the ſurface of the earth became warmer.

*March* 18, 1785. There has been a long froſt; a few days ago the barometer ſunk to 29½, and the froſt became more ſevere. Becauſe the air being expanded by a part of the preſſure being taken off became colder. This day the mercury roſe to 30, and the froſt ceaſed, the wind continuing as before between north and eaſt. *March* 19. Mercury above 30, weather ſtill milder, no froſt, wind north-eaſt. *March* 20. The ſame, for the mercury riſing ſhews that the air becomes more compreſſed by the weight above, and in conſequence gives out warmth.

*April* 4, 5. Froſt, wind north-eaſt, the wind changed in the middle of the day to the north-weſt without rain, and has done ſo for three or four days, becoming again north-eaſt at night. For the ſun now giving greater degrees of heat, the air aſcends as the ſun paſſes the zenith, and is ſupplied below by the air on the weſtern ſide as well as on the eaſtern ſide of the zenith during the hot part of the day; whence for a few hours, on the approach of the hot part of the day, the air acquires a weſterly direction in this longitude. If the north-weſt wind had been cauſed by a retrograde motion of ſome ſouthern air, which had paſſed over us, it would have been attended with rain or clouds.

*April* 10. It rained all day yeſterday, the wind north-weſt, this morning there was a ſharp froſt. The evaporation of the moiſture, (which fell yeſterday) occaſioned by the continuance of the wind, produced ſo much cold as to freeze the dew.

*May* 12. Frequent ſhowers with a current of colder wind preceding every ſhower. The ſinking of the rain or cloud preſſed away the air from beneath it in its deſcent, which having been for a time ſhaded from the ſun by the floating cloud, became cooled in ſome degree.

*June* 20. The barometer ſunk, the wind became ſouth-weſt, and the whole heaven was inſtantly covered with clouds. A part of the incumbent atmoſphere having vaniſhed, as appeared by the ſinking of the barometer, the remainder became expanded by its elaſticity, and thence attracted ſome of the matter of heat from the vapour intermixed with it, and thus in a few minutes a total devaporation took place, as in exhauſting the receiver of an air-pump. See note XXV. At the place where the air is deſtroyed, currents both from the north and ſouth flow in to ſupply the deficiency, (for it has been ſhewn that there are no other proper winds but theſe two) and the mixture of theſe winds produces ſo ſudden condenſation of the moiſture, both by the coldneſs of the northern air and the expanſion of both of them, that lightning is given out, and an incipient tornado takes place; whence thunder is ſaid frequently to approach againſt the wind.

*Auguſt* 28, 1732. Barometer was at 31, and *Dec.* 30, in the ſame year, it was at 28 2-tenths. Medical Eſſays, Edinburgh, Vol. II. p. 7. It appears from theſe journals that the mercury at Edinburgh varies ſometimes nearly three inches, or one-tenth of the whole atmoſphere. From the journals kept by the Royal Society at London it appears ſeldom to vary more than two inches, or one-fifteenth of the whole atmoſphere. The quantity of the variation is ſaid ſtill to decreaſe nearer the line, and to increaſe in the more northern latitudes; which much confirms the idea that there exiſts at certain times a great deſtruction or production of air within the polar circle.

*July* 2, 1732. The weſterly winds in the journal in the Medical Eſſays, Vol. II. above referred to, are frequently marked with the number three to ſhew their greater velocity, whereas the eaſterly winds ſeldom approach to the number two. The greater velocity of the weſterly winds than the eaſterly ones is well known I believe in every climate of the world; which may be thus explained from the theory above delivered. 1. When the air is ſtill, the higher parts of the atmoſphere move quicker than thoſe parts which touch the earth, becauſe they are at a greater diſtance from the axis of motion. 2. The part of the atmoſphere where the north or ſouth wind comes from is higher than the part of it where it comes to, hence the more elevated parts of the atmoſphere continue to deſcend towards the earth as either of thoſe winds approach. 3. When ſouthern air is brought to us it poſſeſſes a weſterly direction alſo, owing to the velocity it had previouſly acquired from the earth's ſurface; and if it conſiſts of air from the higher parts of the atmoſphere deſcending nearer the earth, this weſterly velocity becomes increaſed. But when northern air is brought to us, it poſſeſſes an apparent eaſterly direction alſo, owing to the velocity which it had previouſly acquired from the earth's ſurface being leſs than that of the earth's ſurface in this latitude; now if the north-eaſt wind conſiſts of air deſcending from higher parts of the atmoſphere, this deficiency of velocity will be leſs, in conſequence of the ſame cauſe, viz. The higher parts of the atmoſphere deſcending, as the wind approaches, increaſes the real velocity of the weſtern winds, and decreaſes the apparent velocity of the eaſtern ones.

*October* 22. Wind changed from ſouth-eaſt to ſouth-weſt. There is a popular prognoſtication that if the wind changes from the north towards the ſouth paſſing through the eaſt, it is more likely to continue in the ſouth, than if it paſſes through the weſt, which may be thus accounted for. If the north-eaſt wind changes to a north-weſt wind, it ſhews either that a part of the northern air deſcends upon us in a ſpiral eddy, or that a ſuperior current of ſouthern air is driven back; but if a north-eaſt wind be changed into a ſouth-eaſt wind it ſhews that the northern air is become retrograde, and that in a day or two, as ſoon as that part of it has paſſed, which has not gained the velocity of the earth's ſurface in this latitude, it will become a ſouth wind for a few hours, and then a ſouth-weſt wind.

The writer of this imperfect ſketch of anemology wiſhes it may incite ſome perſon of greater leiſure and ability to attend to this ſubject, and by comparing the various meteorological journals and obſervations already publiſhed, to conſtruct a more accurate and methodical treatiſe on this intereſting branch of philoſophy.

## NOTE XXXIV.——VEGETABLE PERSPIRATION.

*And wed the enamoured Oxygene to Light.*

CANTO IV. l. 34.

WHEN points or hairs are put into ſpring-water, as in the experiments of Sir B. Thompſon, (Philoſ. Tranſ. Vol. LXXVII.) and expoſed to the light of the ſun, much air, which looſely adhered to the water, riſes in bubbles, as explained in note on Fucus, Vol. II. A ſtill greater quantity of air, and of a purer kind, is emitted by Dr. Prieſtley's green matter, and by vegetable leaves growing in water in the ſun-ſhine, according to Mr. Ingenhouze's experiments; both which I ſuſpect to be owing to a decompoſition of the water perſpired by the plant, for the edge of a capillary tube of great tenuity may be conſidered as a circle of points, and as the oxygene, or principle of vital air, may be expanded into a gas by the ſun's light; the hydrogene or inflammable air may be detained in the pores of the vegetable.

Hence plants growing in the ſhade are white, and become green by being expoſed to the ſun's light; for their natural colour being blue, the addition of hydrogene adds yellow to this blue, and *tans* them green. I ſuppoſe a ſimilar circumſtance takes place in animal bodies; their perſpirable matter as it eſcapes in the ſun-ſhine becomes decompoſed by the edges of their pores as in vegetables, though in leſs quantity, as their perſpiration is leſs, and by the hydrogene being retained the ſkin becomes *tanned* yellow. In proof of this it muſt be obſerved that both vegetable and animal ſubſtances become bleached white by the ſun-beams when they are dead, as cabbage-ſtalks, bones, ivory, tallow, bees-wax, linen and cotton cloth; and hence I ſuppoſe the copper-coloured natives of ſunny countries might become etiolated or blanched by being kept from their infancy in the dark, or removed, for a few generations to more northerly climates.

It is probable that on a ſunny morning much pure air becomes ſeparated from the dew by means of the points of vegetables on which it adheres, and much inflammable air imbibed by the vegetable, or combined with it; and by the ſun's light thus decompoſing water the effects of it in bleaching linen ſeems to depend (as deſcribed in Note X.): the water is decompoſed by the light at the ends or points of the cotton or thread, and the vital air unites with the phlogiſtic, or colouring matters of the cloth, and produces a new acid, which is either itſelf colourleſs or waſhes out, at the ſame time the inflammable part of the water eſcapes. Hence there ſeems a reaſon why cotton bleaches ſo much ſooner than linen, viz. becauſe its fibres are three or four times ſhorter, and therefore protrude ſo many more points, which ſeem to facilitate the liberation of the vital air from the inflammable part of the water.

Bee's wax becomes bleached by expoſure to the ſun and dews in a ſimilar manner as metals become calcined or ruſty, viz. by the water on their ſurface being decompoſed; and hence the inflammable material which cauſed the colour becomes united with vital air forming a new acid, and is waſhed away.

Oil cloſe ſtopped in a phial not full, and expoſed long to the ſun's light, becomes bleached, as I ſuppoſe, by the decompoſition of the water it contains; the inflammable air riſing above the ſurface, and the vital air uniting with the colouring matter of the oil. For it is remarkable, that by ſhutting up a phial of bleached oil in a dark drawer, it in a little time becomes coloured again.

The following experiment ſhews the power of light in ſeparating vital air from another baſis, viz. from azote. Mr. Scheel inverted a glaſs veſſel filled with colourleſs nitrous acid into another glaſs containing the ſame acid, and on expoſing them to the ſun's light, the inverted glaſs became partly filled with pure air, and the acid at the ſame time became coloured. Scheel in Crell's Annal. 1786. But if the veſſel of colourleſs nitrous acid be quite full and ſtopped, ſo that no ſpace is left for the air produced to expand itſelf into, no change of colour takes place. Prieſtley's Exp. VI. p. 344. See Keir's very excellent Chemical Dictionary, p. 99. new edition

A ſun-flower three feet and half high according to the experiment of Dr. Hales, perſpired two pints in one day (Vegetable Statics.) which is many times as much in proportion to its ſurface as is perſpired from the ſurface and lungs of animal bodies; it follows that the vital air liberated from the ſurfaces of plants by the ſunſhine muſt much exceed the quantity of it abſorbed by their reſpiration, and that hence they improve the air in which they live during the light part of the day, and thus blanched vegetables will ſooner become *tanned into green* by the ſun's light, than etiolated animal bodies will become *tanned yellow* by the ſame means.

It is hence evident, that the curious diſcovery of Dr. Prieſtley, that his green vegetable matter and other aquatic plants gave out vital air when the ſun ſhone upon them, and the leaves of other plants did the ſame when immerſed in water, as obſerved by Mr. Ingenhouze, refer to the perſpiration of vegetables not to their reſpiration. Becauſe Dr. Prieſtley obſerved the pure air to come from both ſides of the leaves and even from the ſtalks of a water-flag, whereas one ſide of the leaf only ſerves the office of lungs, and certainly not the ſtalks. Exper. on Air, Vol. III. And thus in reſpect to the circumſtance in which plants and animals ſeemed the furthermoſt removed from each other, I mean in their ſuppoſed mode of reſpiration, by which one was believed to purify the air which the other had injured, they ſeem to differ only in degree, and the analogy between them remains unbroken.

Plants are ſaid by many writers to grow much faſter in the night than in the day; as is particularly obſervable in ſeedlings at their riſing out of the ground. This probably is a conſequence of their ſleep rather than of the abſence of light; and in this I ſuppoſe they alſo reſemble animal bodies.

# NOTE XXXV.——VEGETABLE PLACENTATION.

*While in bright veins the ſilvery ſap aſcends.*
CANTO IV. l. 419.

AS buds are the viviparous offspring of vegetables, it becomes neceſſary that they ſhould be furniſhed with placental veſſels for their nouriſhment, till they acquire lungs or leaves for the purpoſe of elaborating the common juices of the earth into nutriment. Theſe veſſels exiſt in bulbs and in ſeeds, and ſupply the young plant with a ſweet juice till it acquires leaves, as is ſeen in converting barley into malt, and appears from the ſweet taſte of onions and potatoes, when they begin to grow.

The placental veſſels belonging to the buds of trees are placed about the roots of moſt, as the vine; ſo many roots are furniſhed with ſweet or mealy matter, as fern-root, bryony, carrot, turnip, potatoe, or in the alburnum or ſap-wood as in thoſe trees which produce manna, which is depoſited about the month of Auguſt, or in the joints of ſugar cane, and graſſes; early in the ſpring the abſorbent mouths of theſe veſſels drink up moiſture from the earth, with a ſaccharine matter lodged for that purpoſe during the preceding autumn, and puſh this nutritive fluid up the veſſels of the alburnum to every individual bud, as is evinced by the experiments of Dr. Hales, and of Mr. Walker in the Edinburgh Philoſophical Tranſ. The former obſerved that the ſap from the ſtump of a vine, which he had cut off in the beginning of April, aroſe twenty-one feet high in tubes affixed to it for that purpoſe, but in a few weeks it ceaſed to bleed at all, and Dr. Walker marked the progreſs of the aſcending ſap, and found likewiſe that as ſoon as the leaves became expanded the ſap ceaſed to riſe; the aſcending juice of ſome trees is ſo copious and ſo ſweet during the ſap-ſeaſon that it is uſed to make wine as the birch, betula, and ſycamore, acer pſeudo-platinus, and particularly the palm.

During this aſcent of the ſap-juice each individual leaf-bud expands its new leaves, and ſhoots down new roots, covering by their intertexture the old bark with a new one; and as ſoon as theſe new roots (or bark) are capable of abſorbing ſufficient juices from the earth for the ſupport of each bud, and the new leaves are capable of performing their office of expoſing theſe juices to the influence of the air; the placental veſſels ceaſe to act, coaleſce, and are transformed from ſap-wood, or alburnum, into inert wood; ſerving only for the ſupport of the new tree, which grows over them.

Thus from the pith of the new bud of the horſe-cheſnut five veſſels paſs out through the circle of the placental veſſels above deſcribed, and carry with them a minuter circle of thoſe veſſels; theſe five bundles of veſſels unite after their exit, and form the foot-ſtalk or petiole of the new five-fingered leaf, to be ſpoken of hereafter. This ſtructure is well ſeen by cutting off a leaf of the horſe-cheſnut (Æſculus Hippocaſtanum) in September before it falls, as the buds of this tree are ſo large that the flower may be ſeen in them with the naked eye.

After a time, perhaps about midſummer, another bundle of veſſels paſſes from the pith through the alburnum or ſap-veſſels in the boſom of each leaf, and unites by the new bark with the leaf, which becomes either a flower-bud or a leaf-bud to be expanded in the enſuing ſpring, for which purpoſe an apparatus of placental veſſels are produced with proper nutriment during the progreſs of the ſummer and autumn, and thus the vegetable becomes annually increaſed, ten thouſand buds often exiſting on one tree, according to the eſtimate of Linneus. Phil. Bot.

The vaſcular connection of vegetable buds with the leaves in whoſe boſoms they are formed is confirmed by the following experiment, (Oct. 20, 1781.) On the extremity of a young bud of the Mimoſa (ſenſitive plant) a ſmall drop of acid of vitriol was put by means of a pen, and, after a few ſeconds, the leaf in whoſe axilla it dwelt cloſed and opened no more, though the drop of vitriolic acid was ſo ſmall as apparently only to injure the ſummit of the bud. Does not this ſeem to ſhew that the leaf and its bud have connecting veſſels though they ariſe at different times and from different parts of the medulla or pith? And, as it exiſts previouſly to it, that the leaf is the parent of the bud?

This placentation of vegetable buds is clearly evinced from the ſweetneſs of the riſing ſap, and from its ceaſing to riſe as ſoon as the leaves are expanded, and thus compleats the analogy between buds and bulbs. Nor need we wonder at the length of the umbilical cords of buds ſince that muſt correſpond with their ſituation on the tree, in the ſame manner as their lymphatics and arteries are proportionally elongated.

It does not appear probable that any umbilical artery attends theſe placental abſorbents, ſince, as there ſeems to be no ſyſtem of veins in vegetables to bring back the blood from the extremities of their arteries, (except their pulmonary veins,) there could not be any vegetable fluids to be returned to their placenta, which in vegetables ſeems to be ſimply an organ for nutrition, whereas the placenta of the animal fœtus ſeems likewiſe to ſerve as a reſpiratory organ like the gills of fiſhes.

# NOTE XXXVI.——VEGETABLE CIRCULATION.

*And refluent blood in milky eddies bends.*

CANTO IV. l. 420.

THE individuality of vegetable buds was ſpoken of before, and is confirmed by the method of raiſing all kinds of trees by Mr. Barnes. (Method of propagating Fruit Trees. 1759. Lond. Baldwin.) He cut a branch into as many pieces as there were buds or leaves upon it, and wiping the two wounded ends dry he quickly applied to each a cement, previouſly warmed a little, which conſiſted principally of pitch, and planted them in the earth. The uſe of this cement I ſuppoſe to conſiſt in its preventing the bud from bleeding to death, though the author aſcribes it to its antiſceptic quality.

Theſe buds of plants, which are thus each an individual vegetable, in many circumſtances reſemble individual animals, but as animal bodies are detached from the earth, and move from place to place in ſearch of food, and take that food at conſiderable intervals of time, and prepare it for their nouriſhment within their own bodies after it is taken, it is evident they muſt require many organs and powers which are not neceſſary to a ſtationary bud. As vegetables are immoveably fixed to the ſoil from whence they draw their nouriſhment ready prepared, and this uniformly not at returning intervals, it follows that in examining their anatome we are not to look for muſcles of locomotion, as arms and legs; nor for organs to receive and prepare their nouriſhment, as a ſtomach and bowels; nor for a reſervoir for it after it is prepared, as a general ſyſtem of veins, which in locomotive animals contains and returns the ſuperfluous blood which is left after the various organs of ſecretion have been ſupplied, by which contrivance they are enabled to live a long time without new ſupplies of food.

The parts which we may expect to find in the anatome of vegetables correſpondent to thoſe in the animal economy are. 1. A ſyſtem of abſorbent veſſels to imbibe the moiſture of the earth ſimilar to the lacteal veſſels, as in the roots of plants; and another ſyſtem of abſorbents ſimilar to the lymphatics of animal bodies, opening its mouths on the internal cells and external ſurfaces of vegetables; and a third ſyſtem of abſorbent veſſels correſpondent with thoſe of the placentation of the animal fœtus. 2. A pulmonary ſyſtem correſpondent to the lungs or gills of quadrupeds and fiſh, by which the fluid abſorbed by the lacteals and lymphatics may be expoſed to the influence of the air, this is done by the green leaves of plants, thoſe in the air reſembling lungs, and thoſe in the water reſembling gills; and by the petals of flowers. 3. Arterial ſyſtems to convey the fluid thus elaborated to the various glands of the vegetable for the purpoſes of its growth, nutrition, and various ſecretions. 4. The various glands which ſeparate from the vegetable blood the honey, wax, gum, reſin, ſtarch, ſugar, eſſential oil, &c. 5. The organs adapted for their propagation or reproduction. 6. Muſcles to perform ſeveral motions of their parts.

I. The exiſtence of that branch of the abſorbent veſſels of vegetables which reſembles the lacteals of animal bodies, and imbibes their nutriment from the moiſt earth, is evinced by their growth ſo long as moiſture is applied to their roots, and their quickly withering when it is withdrawn.

Beſides theſe abſorbents in the roots of plants there are others which open their mouths on the external ſurfaces of the bark and leaves, and on the internal ſurfaces of all the cells, and between the bark and the alburnum or ſap-wood; the exiſtence of theſe is ſhewn, becauſe a leaf plucked off and laid with its under ſide on water will not wither ſo ſoon as if left in the dry air,—the ſame if the bark alone of a branch which is ſeparated from a tree be kept moiſt with water,—and laſtly, by moiſtening the alburnum or ſap-wood alone of a branch detached from a tree it will not ſo ſoon wither as if left in the dry air. By the following experiment theſe veſſels were agreeably viſible by a common magnifying glaſs, I placed in the ſummer of 1781 the footſtalks of ſome large fig-leaves about an inch deep in a decoction of madder, (rubia tinctorum,) and others in a decoction of logwood, (hæmatoxylum campechenſe,) along with ſome ſprigs cut off from a plant of picris, theſe plants were choſen becauſe their blood is white, after ſome hours, and on the next day, on taking out either of theſe and cutting off from its bottom about a quarter of an inch of the ſtalk an internal circle of red points appeared, which were the ends of abſorbent veſſels coloured red with the decoction, while an external ring of arteries was ſeen to bleed out haſtily a milky juice, and at once evinced both the abſorbent and arterial ſyſtem. Theſe abſorbent veſſels have been called by Grew, and Malphigi, and ſome other philoſophers, bronchi, and erroneouſly ſuppoſed to be air-veſſels. It is probable that theſe veſſels, when cut through, may effuſe their fluids, and receive air, their ſides being too ſtiff to collapſe; ſince dry wood emits air-bubbles in the exhauſted receiver in the ſame manner as moiſt wood.

The ſtructure of theſe vegetable abſorbents conſiſts of a ſpiral line, and not of a veſſel interrupted with valves like the animal lymphatics, ſince on breaking almoſt any tender leaf and drawing out ſome of the fibres which adhere longeſt this ſpiral ſtructure becomes viſible even to the naked eye, and diſtinctly ſo by the uſe of a common lens.

In ſuch a ſtructure it is eaſy to conceive how a vermicular or periſtaltic motion of the veſſel beginning at the loweſt part of it, each ſpiral ring ſucceſſively contracting itſelf till it fills up the tube, muſt forcibly puſh forwards its contents, as from the roots of vines in the bleeding ſeaſon; and if this vermicular motion ſhould begin at the upper end of the veſſel it is as eaſy to ſee how it muſt carry its contained fluid in a contrary direction. The retrograde motion of the vegetable abſorbent veſſels is ſhewn by cutting a forked branch from a tree, and immerſing a part of one of the forks in water, which will for many days prevent the other from withering; or it is ſhewn by planting a willow branch with the wrong end upwards. This ſtructure in ſome degree obtains in the oeſophagus or throat of cows, who by ſimilar means convey their food firſt downwards and afterward upwards by a retrograde motion of the annularm uſcles or cartilages for the purpoſe of a ſecond maſtication of it.

II. The fluids thus drank up by the vegetable abſorbent veſſels from the earth, or from the atmoſphere, or from their own cells and interſtices, are carried to the foot-ſtalk of every leaf, where the abſorbents belonging to each leaf unite into branches, forming ſo many pulmonary arteries, and are thence diſperſed to the extremities of the leaf, as may be ſeen in cutting away ſlice after ſlice the footſtalk of a horſe-cheſnut in September before the leaf falls. There is then a compleat circulation in the leaf, a pulmonary vein receiving the blood from the extremities of each artery on the upper ſide of the leaf, and joining again in the footſtalk of the leaf theſe veins produce ſo many arteries, or aortas, which diſperſe the new blood over the new bark, elongating its veſſels, or producing its ſecretions; but as a reſervoir of blood could not be wanted by a vegetable bud which takes in its nutriment at all times, I imagine there is no venous ſyſtem, no veins properly ſo called, which receive the blood which was to ſpare, and return it into the pulmonary or arterial ſyſtem.

The want of a ſyſtem of veins was countenanced by the following experiment; I cut off ſeveral ſtems of tall ſpurge, (Euphorbia helioſcopia) in autumn, about the centre of the plant, and obſerved tenfold the quantity of milky juice ooze from the upper than from the lower extremity, which could hardly have happened if there had been a venous ſyſtem of veſſels to return the blood from the roots to the leaves.

Thus the vegetable circulation, complete in the lungs, but probably in the other part of the ſyſtem deficient in reſpect to a ſyſtem of returning veins, is carried forwards without a heart, like the circulation through the livers of animals where the blood brought from the inteſtines and meſentery by one vein is diſperſed through the liver by the vena portarum, which aſſumes the office of an artery. See Note XXXVII.

At the ſame time ſo minute are the veſſels in the intertexture of the barks of plants, which belong to each individual bud, that a general circulation may poſſibly exiſt, though we have not yet been able to diſcover the venous part of it.

There is however another part of the circulation of vegetable juices viſible to the naked eye, and that is in the corol or petals of flowers, in which a part of the blood of the plant is expoſed to the influence of the air and light in the ſame manner as in the foliage, as will be mentioned more at large in Notes XXXVII and XXXIX.

Theſe circulations of their reſpective fluids ſeem to be carried on in the veſſels of plants preciſely as in animal bodies by their irritability to the ſtimulus of their adapted fluids, and not by any mechanical or chemical attraction, for their abſorbent veſſels propel the juice upwards, which they drink up from the earth, with great violence; I ſuppoſe with much greater than is exerted by the lacteals of animals, probably owing to the greater minuteneſs of theſe veſſels in vegetables and the greater rigidity of their coats. Dr. Hales in the ſpring ſeaſon cut off a vine near the ground, and by fixing tubes on the remaining ſtump of it, found the ſap to riſe twenty-one feet in the tube by the propulſive power of theſe abſorbents of the roots of it. Veget. Stat. p. 102. Such a power can not be produced by capillary attraction, as that could only raiſe a fluid nearly to the upper edge of the attracting cylinder, but not enable it to flow over that edge, and much leſs to riſe 21 feet above it. What then can this power be owing to? Doubtleſs to the living activity of the abſorbent veſſels, and to their increaſed vivacity from the influence of the warmth of the ſpring ſucceeding the winter's cold, and their thence greater ſuſceptibility to irritation from the juices which they abſorb, reſembling in all circumſtances the action of the living veſſels of animals.

# NOTE XXXVII.——VEGETABLE RESPIRATION.

*While ſpread in air the leaves reſpiring play.*
CANTO IV. l. 421.

I. THERE have been various opinions concerning the uſe of the leaves of plants in the vegetable œconomy. Some have contended that they are perſpiratory organs; this does not ſeem probable from an experiment of Dr. Hales, Veg. Stat. p. 30. He found by cutting off branches of trees with apples on them, and taking off the leaves, that an apple exhaled about as much as two leaves, the ſurfaces of which were nearly equal to the apple; whence it would appear that apples have as good a claim to be termed perſpiratory organs as leaves. Others have believed them excretory organs of excrementious juices; but as the vapour exhaled from vegetables has no taſte, this idea is no more probable than the other; add to this that in moiſt weather, they do not appear to perſpire or exhale at all.

The internal ſurface of the lungs or air-veſſels in men, are ſaid to be equal to the external ſurface of the whole body, or about fifteen ſquare feet; on this ſurface the blood is expoſed to the influence of the reſpired air through the medium however of a thin pellicle; by this expoſure to the air it has its colour changed from deep red to bright ſcarlet, and acquires ſomething ſo neceſſary to the exiſtence of life, that we can live ſcarcely a minute without this wonderful proceſs.

The analogy between the leaves of plants and the lungs or gills of animals ſeems to embrace ſo many circumſtances, that we can ſcarcely withhold our aſſent to their performing ſimilar offices.

1. The great ſurface of the leaves compared to that of the trunk and branches of trees is ſuch, that it would ſeem to be an organ well adapted for the purpoſe of expoſing the vegetable juices to the influence of the air; this however we ſhall ſee afterwards is probably performed only by their upper ſurfaces, yet even in this caſe the ſurface of the leaves in general bear a greater proportion to the ſurface of the tree, than the lungs of animals to their external ſurfaces.

2. In the lungs of animals, the blood after having been expoſed to the air in the extremities of the pulmonary artery, is changed in colour from deep red to bright ſcarlet, and certainly in ſome of its eſſential properties; it is then collected by the pulmonary vein and returned to the heart. To ſhew a ſimilarity of circumſtance in the leaves of plants the following

experiment was made, June 24, 1781: A ſtalk with leaves and ſeed-veſſels of large ſpurge (Euphorbia helioſcopia) had been ſeveral days placed in a decoction of madder (Rubia tinctorum) ſo that the lower part of the ſtem, and two of the undermoſt leaves were immerſed in it. After having waſhed the immerſed leaves in clear water, I could readily diſcern the colour of the madder paſſing along the middle rib of each leaf. This red artery was beautifully viſible both on the under and upper ſurface of the leaf; but on the upper ſide many red branches were ſeen going from it to the extremities of the leaf, which on the other ſide were not viſible except by looking through it againſt the light. On this under ſide a ſyſtem of branching veſſels carrying a pale milky fluid were ſeen coming from the extremities of the leaf, and covering the whole underſide of it, and joining into two large veins, one on each ſide of the red artery in the middle rib of the leaf, and along with it deſcending to the footſtalk or petiole. On ſlitting one of theſe leaves with ſciſſars, and having a common magnifying lens ready, the milky blood was ſeen oozing out of the returning veins on each ſide of the red artery in the middle rib, but none of the red fluid from the artery.

All theſe appearances were more eaſily ſeen in a leaf of Picris treated in the ſame manner; for in this milky plant the ſtems and middle rib of the leaves are ſometimes naturally coloured reddiſh, and hence the colour of the madder ſeemed to paſs further into the ramifications of their leaf-arteries, and was there beautifully viſible with the returning branches of milky veins on each ſide.

3. From theſe experiments the upper ſurface of the leaf appeared to be the immediate organ of reſpiration, becauſe the coloured fluid was carried to the extremities of the leaf by veſſels moſt conſpicuous on the upper ſurface, and there changed into a milky fluid, which is the blood of the plant, and then returned by concomitant veins on the under ſurface, which were ſeen to ooze when divided with ſciſſars, and which in Picris, particularly render the under ſurface of the leaves greatly whiter than the upper one.

4. As the upper ſurface of leaves conſtitutes the organ of reſpiration, on which the ſap is expoſed in the terminations of arteries beneath a thin pellicle to the action of the atmoſphere, theſe ſurfaces in many plants ſtrongly repel moiſture, as cabbage-leaves, whence the particles of rain lying over their ſurfaces without touching them, as obſerved by Mr. Melville (Eſſays Literary and Philoſop. Edinburgh) have the appearance of globules of quickſilver. And hence leaves laid with the upper ſurfaces on water, wither as ſoon as in the dry air, but continue green many days,

if placed with the under ſurfaces on water, as appears in the experiments of Monſ. Bonnet (Uſage des Fevilles.) Hence ſome aquatic plants, as the Water-lily (Nymphœa) have the lower ſides of their leaves floating on the water, while the upper ſurfaces remain dry in the air.

5. As thoſe inſects, which have many ſpiracula, or breathing apertures, as waſps and flies, are immediately ſuffocated by pouring oil upon them, I carefully covered with oil the ſurfaces of ſeveral leaves of Phlomis, of Portugal Laurel, and Balſams, and though it would not regularly adhere, I found them all die in a day or two.

Of aquatic leaves, ſee Note on Trapa and on Fucus, in Vol. II. to which muſt be added that many leaves are furniſhed with muſcles about their footſtalks, to turn their upper ſurfaces to the air or light, as Mimoſa and Hedyſarum gyrans. From all theſe analogies I think there can be no doubt but that leaves of trees are their lungs, giving out a phlogiſtic material to the atmoſphere, and abſorbing oxygene or vital air.

6. The great uſe of light to vegetation would appear from this theory to be by diſengaging vital air from the water which they perſpire, and thence to facilitate its union with their blood expoſed beneath the thin ſurface of their leaves; ſince when pure air is thus applied, it is probable, that it can be more readily abſorbed. Hence in the curious experiments of Dr. Prieſtley and Mr. Ingenhouze, ſome plants purified air leſs than others, that is, they perſpired leſs in the ſunſhine; and Mr. Scheele found that by putting peas into water, which about half-covered them, that they converted the vital air into fixed air, or carbonic acid gas, in the ſame manner as in animal reſpiration. See Note XXXIV.

7. The circulation in the lungs or leaves of plants is very ſimilar to that of fiſh. In fiſh the blood after having paſſed through their gills does not return to the heart as from the lungs of air-breathing animals, but the pulmonary vein taking the ſtructure of an artery after having received the blood from the gills, which there gains a more florid colour, diſtributes it to the other parts of their bodies. The ſame ſtructure occurs in the livers of fiſh, whence we ſee in thoſe animals two circulations independent of the power of the heart, viz. that beginning at the termination of the veins of the gills, and branching through the muſcles; and that which paſſes through the liver; both which are carried on by the action of thoſe reſpective arteries and veins. Monro's Phyſiology of Fiſh, p. 19.

The courſe of the fluids in the roots, leaves, and buds of vegetables ſeems to be performed in a manner ſimilar to both theſe. Firſt the abſorbent veſſels of the roots and ſurfaces unite at the footſtalk of the leaf; and then, like the Vena Portarum, an artery commences without the intervention of a heart, and ſpreads the ſap in its numerous ramifications on the upper ſurface of the leaf; here it changes its colour and properties, and becomes vegetable blood; and is again collected by a pulmonary vein on the under ſurface of the leaf. This vein, like that which receives the blood from the gills of fiſh, aſſumes the office and name of an artery, and branching again diſperſes the blood upward to the bud from the footſtalk of the leaf, and downward to the roots; where it is all expended in the various ſecretions, the nouriſhment and growth of the plant, as faſt as it is prepared.

II. The organ of reſpiration already ſpoken of belongs particularly to the ſhoots or buds, but there is another pulmonary ſyſtem, perhaps totally independent of the green foliage, which belongs to the fructification only, I mean the corol or petals. In this there is an artery belonging to each petal, which conveys the vegetable blood to its extremities, expoſing it to the light and air under a delicate membrane covering the internal ſurface of the petal, where it often changes its colour, as is beautifully ſeen in ſome party-coloured poppies; though it is probable ſome of the irideſcent colours of flowers may be owing to the different degrees of tenuity of the exterior membrane of the leaf refracting the light like ſoap-bubbles, the vegetable blood is then returned by correſpondent vegetable veins, exactly as in the green foliage; for the purpoſes of the important ſecretions of honey, wax, the finer eſſential oil, and the prolific duſt of the anthers.

1. The vaſcular ſtructure of the corol as above deſcribed, and which is viſible to the naked eye, and its expoſing the vegetable juices to the air and light during the day, evinces that it is a pulmonary organ.

2. As the glands which produce the prolific duſt of the anthers, the honey, wax, and frequently ſome odoriferous eſſential oil, are generally attached to the corol, and always fall off and periſh with it, it is evident that the blood is elaborated or oxygenated in this pulmonary ſyſtem for the purpoſe of theſe important ſecretions.

3. Many flowers, as the Colchicum, and Hamamelis ariſe naked in autumn, no green leaves appearing till the enſuing ſpring; and many others put forth their flowers and complete their impregnation early in the ſpring before the green foliage appears, as Mezereon, cherries, pears, which ſhews that theſe corols are the lungs belonging to the fructification.

4. This organ does not ſeem to have been neceſſary for the defence of the ſtamens and piſtils, ſince the calyx of many flowers, as Tragopogon, performs this office; and in many flowers theſe petals themſelves are ſo

tender as to require being ſhut up in the calyx during the night, for what other uſe then can ſuch an apparatus of veſſels be deſigned?

5. In the Helleborus-niger, Chriſtmas-roſe, after the ſeeds are grown to a certain ſize, the nectaries and ſtamens drop off, and the beautiful large white petals change their colour to a deep green, and gradually thus become a calyx incloſing and defending the ripening ſeeds, hence it would ſeem that the white veſſels of the corol ſerved the office of expoſing the blood to the action of the air, for the purpoſes of ſeparating or producing the honey, wax, and prolific duſt, and when theſe were no longer wanted, that theſe veſſels coaleſced like the placental veſſels of animals after their birth, and thus ceaſed to perform that office and loſt at the ſame time their white colour. Why ſhould they loſe their white colour, unleſs they at the ſame time loſt ſome other property beſides that of defending the ſeed-veſſel, which they ſtill continue to defend?

6. From theſe obſervations I am led to doubt whether green leaves be abſolutely neceſſary to the progreſs of the fruit-bud after the laſt year's leaves are fallen off. The green leaves ſerve as lungs to the ſhoots and foſter the new buds in their boſoms, whether theſe buds be leaf-buds or fruit-buds; but in the early ſpring the fruit-buds expand their corols, which are their lungs, and ſeem no longer to require green leaves; hence the vine bears fruit at one joint without leaves, and puts out a leaf-bud at another joint without fruit. And I ſuppoſe the green leaves which riſe out of the earth in the ſpring from the Colchicum are for the purpoſe of producing the new bulb, and its placenta, and not for the giving maturity to the ſeed. When currant or gooſberry trees loſe their leaves by the depredation of inſects the fruit continues to be formed, though leſs ſweet and leſs in ſize.

7. From theſe facts it appears that the flower-bud after the corol falls off, (which is its lungs,) and the ſtamens and nectary along with it, becomes ſimply an uterus for the purpoſe of ſupplying the growing embryon with nouriſhment, together with a ſyſtem of abſorbent veſſels which bring the juices of the earth to the footſtalk of the fruit, and which there changes into an artery for the purpoſe of diſtributing the ſap for the ſecretion of the ſaccharine or farinaceous or aceſcent materials for the uſe of the embryon. At the ſame time as all the veſſels of the different buds of trees inoſculate or communicate with each other, the fruit becomes ſweeter and larger when the green leaves continue on the tree, but the mature flowers themſelves, (the ſucceeding fruit not conſidered) perhaps ſuffer little injury from the green leaves being taken off, as ſome floriſts have obſerved.

8. That the veſſels of different vegetable buds inoſculate in various parts of their circulation is rendered probable by the increaſed growth of one

bud, when others in its vicinity are cut away; as it thus ſeems to receive the nouriſhment which was before divided amongſt many.

## NOTE XXXVIII.—VEGETABLE IMPREGNATION.

*Love out their hour and leave their lives in air.*

CANTO IV. l. 456.

FROM the accurate experiments and obſervations of Spallanzani it appears that in the Spartium Junceum, ruſh-broom, the very minute ſeeds were diſcerned in the pod at leaſt twenty days before the flower is in full bloom, that is twenty days before fecundation. At this time alſo the powder of the anthers was viſible, but glued faſt to their ſummits. The ſeeds however at this time, and for ten days after the bloſſom had fallen off appeared to conſiſt of a gelatinous ſubſtance. On the eleventh day after the falling of the bloſſom the ſeeds became heart-ſhape, with the baſis attached by an appendage to the pod, and a white point at the apex; this white point was on preſſure found to be a cavity including a drop of liquor.

On the 25th day the cavity which at firſt appeared at the apex was much enlarged and ſtill full of liquor, it alſo contained a very ſmall ſemi-tranſparent body, of a yellowiſh colour, gelatinous, and fixed by its two oppoſite ends to the ſides of the cavity.

In a month the ſeed was much enlarged and its ſhape changed from a heart to a kidney, the little body contained in the cavity was increaſed in bulk and was leſs tranſparent, and gelatinous, but there yet appeared no organization.

On the 40th day the cavity now grown larger was quite filled with the body, which was covered with a thin membrane; after this membrane was removed the body appeared of a bright green, and was eaſily divided by the point of a needle into two portions, which manifeſtly formed the two lobes, and within theſe attached to the lower part the exceedingly ſmall plantule was eaſily perceived.

The foregoing obſervations evince, 1. That the ſeeds exiſt in the ovarium many days before fecundation. 2. That they remain for ſome time ſolid, and then a cavity containing a liquid is formed in them. 3. That after fecundation a body begins to appear within the cavity fixed by two points to the ſides, which in proceſs of time proves to be two lobes containing a plantule. 4. That the ripe ſeed conſiſts of two lobes adhering to a plantule, and ſurrounded by a thin membrane which is itſelf covered with a huſk or cuticle. Spalanzani's Diſſertations, Vol. II. p. 253.

The analogy between ſeeds and eggs has long been obſerved, and is confirmed by the mode of their production. The egg is known to be formed within the hen long before its impregnation: C. F. Wolf aſſerts that the yolk of the egg is nouriſhed by the veſſels of the mother, and that it has from thoſe its arterial and venous branches, but that after impregnation theſe veſſels gradually become impervious and obliterated, and that new ones are produced from the fetus and diſperſed into the yolk. Haller's Phyſiolog. Tom. VIII. p. 24. The young ſeed after fecundation, I ſuppoſe, is nouriſhed in a ſimilar manner from the gelatinous liquor, which is previouſly depoſited for that purpoſe; the uterus of the plant producing or ſecreting it into a reſervoir or amnios in which the embryon is lodged, and that the young embryon is furniſhed with veſſels to abſorb a part of it, as in the very early embryon in the animal uterus.

The ſpawn of frogs and of fiſh is delivered from the female before its impregnation. M. Bonnet ſays that the male ſalamander darts his ſemen into the water, where it forms a little whitiſh cloud which is afterwards received by the ſwoln anus of the female, and ſhe is fecundated.—He adds that marine plants approach near to theſe animals, as the male does not project a fine powder but a liquor which in like manner forms a little cloud in the water.—And futther adds, who knows but the powder of the ſtamina of certain plants may not make ſome impreſſion on certain germs belonging to the animal kingdom! Letter XLIII. to Spalanzani, Oevres Philoſ.

Spalanzani found that the ſeminal fluid of frogs and dogs even when diluted with much water retained its prolific quality. Whether this quality be ſimply a ſtimulus exciting the egg into animal action, which may be called a vivifying principle, or whether part of it be actually conjoined with the egg is not yet determined, though the latter ſeems more probable from the frequent reſemblance of the fetus to the male parent. A conjunction however of both the male and female influence ſeems neceſſary for the purpoſe of reproduction throughout all organized nature, as well in hermaphrodite inſects, microſcopic animals, and polypi, and exiſts as well in the formation of the buds of vegetables as in the production of their ſeeds, which is ingeniouſly conceived and explained by Linneus. After having compared the flower to the larva of a butterfly, conſiſting of petals inſtead of wings, calyxes inſtead of wing-ſheaths, with the organs of reproduction, and having ſhewn the uſe of the farina in fecundating the egg or ſeed, he proceeds to explain the production of the bud. The calyx of a flower, he ſays, is an expanſion of the outer bark, the petals proceed from the inner bark or rind, the ſtamens from the alburnum or woody circle, and the ſtyle from the pith. In the production and impregnation of the ſeed a commixture of the ſecretions of the ſtamens and ſtyle are neceſſary; and for the production of a bud he thinks the medulla or pith burſts its integuments and mixes with the woody part or alburnum, and theſe forcing their paſſage through the rind and bark conſtitute the bud or viviparous progeny of the vegetable. Syſtem of Vegetables tranſlated from Linneus, p. 8.

It has been ſuppoſed that the embryon vegetable after fecundation, by its living activity or ſtimulus exerted on the veſſels of the parent plant, may produce the fruit or ſeed-lobes, as the animal fetus produces its placenta, and as vegetable buds may be ſuppoſed to produce their umbilical veſſels or roots down the bark of the tree. This in reſpect to the production of the fruit ſurrounding the ſeeds of trees has been aſſimilated to the gall-nuts on oak-leaves, and to the bedeguar on briars, but there is a powerful objection to this doctrine, viz. that the fruit of figs, all which are female in this country, grow nearly as large without fecundation, and therefore the embryon has in them no ſelf-living principle.

## NOTE XXXIX.—VEGETABLE GLANDULATION.

*Seeks, where fine pores their dulcet balm diſtil.*
CANTO IV. l. 503.

THE glands of vegetables which ſeparate from their blood the mucilage, ſtarch, or ſugar for the placentation or ſupport of their ſeeds, bulbs, and buds; or thoſe which depoſit their bitter, acrid, or narcotic juices for their defence from depredations of inſects or larger animals; or thoſe which ſecrete reſins or wax for their protection from moiſture or froſts, conſiſt of veſſels too fine for the injection or abſorption of coloured fluids, and have not therefore yet been exhibited to the inſpection even of our glaſſes, and can therefore only be known by their effects, but one of the moſt curious and important of all vegetable ſecretions, that of honey, is apparent to our naked eyes, though before the diſcoveries of Linneus the nectary or honey-gland had not even acquired a name.

The odoriferous eſſential oils of ſeveral flowers ſeem to have been deſigned for their defence againſt the depredations of inſects, while their beautiful colours were a neceſſary conſequence of the ſize of the particles of their blood, or of the tenuity of the exterior membrane of the petal. The uſe of the prolific duſt is now well aſcertained, the wax which covers the anthers prevents this duſt from receiving moiſture, which would make it burſt prematurely and thence prevent its application to the ſtigma, as ſometimes happens in moiſt years and is the cauſe of deficient fecundation both of our fields and orchards.

The univerſality of the production of honey in the vegetable world, and the very complicated apparatus which nature has conſtructed in many flowers, as well as the acrid or deleterious juices ſhe has furniſhed thoſe flowers with (as in the Aconite) to protect this honey from rain and from the depredations of inſects, ſeem to imply that this fluid is of very great importance in the vegetable economy; and alſo that it was neceſſary to expoſe it to the open air previous to its reabſorption into the vegetable veſſels.

In the animal ſyſtem the lachrymal gland ſeparates its fluid into the open air for the purpoſe of moiſtening the eye, of this fluid the part which does not exhale is abſorbed by the puncta lachrymalia and carried into the noſtrils; but as this is not a nutritive fluid the analogy goes no further than its ſecretion into the open air and its reabſorption into the ſyſtem; every other ſecreted fluid in the animal body is in part abſorbed again into the ſyſtem, even thoſe which are eſteemed excrementitious, as the urine and perſpirable matter, of which the latter is ſecreted, like the honey, into the external air. That the honey is a nutritious fluid, perhaps the moſt ſo of any vegetable production, appears from its great ſimilarity to ſugar, and from its affording ſuſtenance to ſuch numbers of inſects, which live upon it ſolely during ſummer, and lay it up for their winter proviſion. Theſe proofs of its nutritive nature evince the neceſſity of its reabſorption into the vegetable ſyſtem for ſome uſeful purpoſe.

This purpoſe however has as yet eſcaped the reſearches of philoſophical botaniſts. M. Pontedera believes it deſigned to lubricate the vegetable uterus, and compares the horn-like nectaries of ſome flowers to the appendicle of the cæcum inteſtinum of animals. (Antholog. p. 49.) Others have ſuppoſed that the honey, when reabſorbed, might ſerve the purpoſe of the liquor amnii, or white of the egg, as a nutriment for the young embryon or fecundated ſeed in its early ſtate of exiſtence. But as the nectary is found equally general in male flowers as in female ones; and as the young embryon or ſeed grows before the petals and nectary are expanded, and after they fall off; and, thirdly, as the nectary ſo ſoon falls off after the fecundation of the piſtullum; theſe ſeem to be inſurmountable objections to both the above-mentioned opinions.

In this ſtate of uncertainty conjectures may be of uſe ſo far as they lead to further experiment and inveſtigation. In many tribes of inſects, as the ſilk-worm, and perhaps in all the moths and butterflies, the male and female parent dies as ſoon as the eggs are impregnated and excluded; the eggs remaining to be perfected and hatched at ſome future time. The ſame thing happens in regard to the male and female parts of flowers; the anthers and filaments, which conſtitute the male parts of the flower, and the ſtigma and ſtyle, which conſtitute the female part of the flower, fall off and die as ſoon as the ſeeds are impregnated, and along with theſe the petals and nectary. Now the moths and butterflies above-mentioned, as ſoon as they acquire the paſſion and the apparatus for the reproduction of their ſpecies, loſe the power of feeding upon leaves as they did before, and become nouriſhed by what?—by honey alone.

Hence we acquire a ſtrong analogy for the uſe of the nectary or ſecretion of honey in the vegetable economy, which is, that the male parts of flowers, and the female parts, as ſoon as they leave their fetus-ſtate, expanding their petals, (which conſtitute their lungs,) become ſenſible to the paſſion, and gain the apparatus for the reproduction of their ſpecies, and are fed and nouriſhed with honey like the inſects above deſcribed; and that hence the nectary begins its office of producing honey, and dies or ceaſes to produce honey at the ſame time with the birth and death of the ſtamens and the piſtils; which, whether exiſting in the ſame or in different flowers, are ſeparate and diſtinct animated beings.

Previous to this time the anthers with their filaments, and the ſtigmas with their ſtyles, are in their fetus-ſtate ſuſtained by their placental veſſels, like the unexpanded leaf-bud; with the ſeeds exiſting in the vegetable womb yet unimpregnated, and the duſt yet unripe in the cells of the anthers. After this period they expand their petals, which have been ſhewn above to conſtitute the lungs of the flower; the placental veſſels, which before nouriſhed the anthers and the ſtigmas, coaleſce or ceaſe to nouriſh them; and they now acquire blood more oxygenated by the air, obtain the paſſion and power of reproduction, are ſenſible to heat, and cold, and moiſture, and to mechanic ſtimulus, and become in reality inſects fed with honey, ſimilar in every reſpect except their being attached to the tree on which they were produced.

Some experiments I have made this ſummer by cutting out the nectaries of ſeveral flowers of the aconites before the petals were open, or had become much coloured, ſome of theſe flowers near the ſummit of the plants produced no ſeeds; others lower down produced ſeeds; but they were not ſufficiently guarded from the farina of the flowers in their vicinity; nor have I had opportunity to try if theſe ſeeds would vegetate.

I am acquainted with a philoſopher, who contemplating this ſubject thinks it not impoſſible, that the firſt inſects were the anthers or ſtigmas of flowers; which had by ſome means looſed themſelves from their parent plant, like the male flowers of Valliſneria; and that many other inſects have gradually in long proceſs of time been formed from theſe; ſome acquiring wings, others fins, and others claws, from their ceaſeleſs efforts to procure their food, or to ſecure themſelves from injury. He contends, that none of theſe changes are more incomprehenſible than the transformation of tadpoles into frogs, and caterpillars into butterflies.

There are parts of animal bodies, which do not require oxygenated blood for the purpoſe of their ſecretions, as the liver; which for the production of bile takes its blood from the meſenteric veins, after it muſt have loſt the whole or a great part of its oxygenation, which it had acquired in its paſſage through the lungs. In like manner the pericarpium or womb of the flower, continues to ſecrete its proper juices for the preſent nouriſhment of the newly animated embryon-ſeed; and the ſaccharine, aceſcent, or ſtarchy matter of the fruit or ſeed-lobes for its future growth; in the ſame manner as theſe things went on before fecundation; that is, without any circulation of juices in the petals, or production of honey in the nectary; theſe having periſhed and fallen off with the male and female apparatus for impregnation.

It is probable that the depredations of inſects on this nutritious fluid muſt be injurious to the products of vegetation, and would be much more ſo, but that the plants have either acquired means to defend their honey in part, or have learned to make more than is abſolutely neceſſary for their own economy. In the ſame manner the honey-dew on trees is very injurious to them; in which diſeaſe the nutritive fluid, the vegetable-ſap-juice, ſeems to be exſuded by a retrograde motion of the cutaneous lymphatics, as in the ſweating ſickneſs of the laſt century. To prevent the depredation of inſects on honey a wealthy man in Italy is ſaid to have poiſoned his neighbour's bees perhaps by mixing arſenic with honey, againſt which there is a moſt flowery declamation in Quintilian. No. XIII. As the uſe of the wax is to preſerve the duſt of the anthers from moiſture, which would prematurely burſt them, the bees which collect this for the conſtruction of the combs or cells, muſt on this account alſo injure the vegetation of a country where they too much abound.

It is not eaſy to conjecture why it was neceſſary that this ſecretion of honey ſhould be expoſed to the open air in the nectary or honey-cup, for which purpoſe ſo great an apparatus for its defence from inſects and from ſhowers became neceſſary. This difficulty increaſes when we recollect that the ſugar in the joints of graſs, in the ſugar-cane, and in the roots of beets, and in ripe fruits is produced without the expoſure to the air. On ſuppoſition of its ſerving for nutriment to the anthers and ſtigmas it may thus acquire greater oxygenation for the purpoſe of producing greater powers of ſenſibility, according to a doctrine lately advanced by a French philoſopher, who has endeavoured to ſhew that the oxygene, or baſe of vital air, is the conſtituent principle of our power of ſenſibility.

From this proviſion of honey for the male and female parts of flowers, and from the proviſion of ſugar, ſtarch, oil, and mucilage, in the fruits, ſeed-cotyledons, roots, and buds of plants laid up for the nutriment of the expanding ſetus, not only a very numerous claſs of inſects, but a great part of the larger animals procure their food; and thus enjoy life and pleaſure without producing pain to others, for theſe ſeeds or eggs with the nutriment laid up in them are not yet endued with ſenſitive life.

The ſecretions from various vegetable glands hardened in the air produce gums, reſins, and various kinds of ſaccharine, ſaponaceous, and wax-like ſubſtances, as the gum of cherry or plumb-trees, gum tragacanth from the aſtragalus tragacantha, camphor from the laurus camphora, elemi from amyris elemifera, aneme from hymenœa courbaril, turpentine from piſtacia terebinthus, balſam of Mecca from the buds of amyris opobalſamum, branches of which are placed in the temples of the Eaſt on account of their fragrance, the wood is called xylobalſamum, and the fruit carpobalſamum; aloe from a plant of the ſame name; myrrh from a plant not yet deſcribed; the remarkably elaſtic reſin is brought into Europe principally in the form of flaſks, which look like black leather, and are wonderfully elaſtic, and not penetrable by water, rectified ether diſſolves it; its flexibility is encreaſed by warmth and deſtroyed by cold; the tree which yields this juice is the jatropha elaſtica, it grows in Guaiana and the neighbouring tracts of America; its juice is ſaid to reſemble wax in becoming ſoft by heat, but that it acquires no elaſticity till that property is communicated to it by a ſecret art, after which it is poured into moulds and well dried and can no longer be rendered fluid by heat. Mr. de la Borde phyſician at Cayenne has given this account. Manna is obtained at Naples from the fraxinus ornus, or manna-aſh, it partly iſſues ſpontaneouſly, which is preferred, and partly exſudes from wounds made purpoſely in the month of Auguſt, many other plants yield manna more ſparingly; ſugar is properly made from the ſaccharum officinale, or ſugar-cane, but is found in the roots of beet and many other plants; American wax is obtained from the myrica cerifera, candle-berry myrtle, the berries are boiled in water and a green wax ſeparates, with luke-warm water the wax is yellow: the ſeed of croton ſebiferum are lodged in tallow; there are many other vegetable exſudations uſed in the various arts of dyeing, varniſhing, tanning. lacquering, and which ſupply the ſhop of the druggiſt with medicines and with poiſons.

There is another analogy, which would ſeem to aſſociate plants with animals, and which perhaps belongs to this Note on Glandulation, I mean the ſimilarity of their digeſtive powers. In the roots of growing vegetables, as in the proceſs of making malt, the farinaceous part of the ſeed is converted into ſugar by the vegetable power of digeſtion in the ſame manner as the farinaceous matter of ſeeds are converted into ſweet chyle by the animal digeſtion. The ſap-juice which riſes in the vernal months from the roots of trees through the alburnum or ſap-wood, owes its ſweetneſs I ſuppoſe to a ſimilar digeſtive power of the abſorbent ſyſtem of the young buds. This exiſts in many vegetables in great abundance as in vines, ſycamore, birch, and moſt abundantly in the palm-tree, (Iſert's Voyage to Guinea,) and ſeems to be a ſimilar fluid in all plants, as chyle is ſimilar in all animals.

Hence as the digeſted food of vegetables conſiſts principally of ſugar, and from that is produced again their mucilage, ſtarch, and oil, and ſince animals are ſuſtained by theſe vegetable productions, it would ſeem that the ſugar-making proceſs carried on in vegetable veſſels was the great ſource of life to all organized beings. And that if our improved chemiſtry ſhould ever diſcover the art of making ſugar from foſſile or aerial matter without the aſſiſtance of vegetation, food for animals would then become as plentiful as water, and mankind might live upon the earth as thick as blades of graſs, with no reſtraint to their numbers but the want of local room.

It would ſeem that roots fixed in the earth, and leaves innumerable waving in the air were neceſſary for the decompoſition of water, and the converſion of it into ſaccharine matter, which would have been not only cumberous but totally incompatible with the locomotion of animal bodies. For how could a man or quadruped have carried on his head or back a foreſt of leaves, or have had long branching lacteal or abſorbent veſſels terminating in the earth? Animals therefore ſubſiſt on vegetables; that is, they take the matter ſo far prepared, and have organs to prepare it further for the purpoſes of higher animation, and greater ſenſibility. In the ſame manner the apparatus of green leaves and long roots were ſound inconvenient for the more animated and ſenſitive parts of vegetable-flowers, I mean the anthers and ſtigmas, which are therefore ſeparate beings, endued with the paſſion and power of reproduction, with lungs of their own, and fed with honey, a food ready prepared by the long roots and green leaves of the plant, and preſented to their abſorbent mouths.

From this outline a philoſopher may catch a glimpſe of the general economy of nature; and like the mariner caſt upon an unknown ſhore, who rejoiced when he ſaw the print of a human foot upon the ſand, he may cry out with rapture, "A God dwells here."

## *The following is an Addition to the Note on Coal,* No. XXIII.

FROM this account of the production of coals from moraſſes it would appear, that coal-beds are not to be expected beneath maſſes of lime-ſtone. Nevertheleſs I have been lately informed by my friend Mr. Mitchell of Thornhill, who I hope will ſoon favour the public with his geological inveſtigations, that the beds of chalk are the uppermoſt of all the limeſtones; and that they reſt on the granulated limeſtone, called ketton-ſtone; which I ſuppoſe is ſimilar to that which covers the whole country from Leadenham to Sleaford, and from Sleaford to Lincoln; and that, thirdly, coal-depths are frequently found beneath theſe two uppermoſt beds of limeſtone.

Now as the beds of chalk and of granulated limeſtone may have been formed by alleviation, on or beneath the ſhores of the ſea, or in vallies of the land; it would ſeem, that ſome coal countries, which in the great commotions of the earth had been ſunk beneath the water, were thus covered with alluvial limeſtone, at well as others with alluvial baſaltes, or common gravel-beds. Very extenſive plains which now conſiſt of alluvial materials, were in the early times covered with water; which has ſince diminiſhed, as the ſolid parts of the earth have increaſed. For the ſolid parts of the earth conſiſting chiefly of animal and vegetable recrements muſt have originally been formed or produced from the water by animal and vegetable proceſſes; and as the ſolid parts of the earth may be ſuppoſed to be thrice as heavy as water, it follows that thrice the quantity of water muſt have vaniſhed compared with the quantity of earth thus produced. This may account for many immenſe beds of alluvial materials, as gravel, rounded ſand, granulated limeſtone, and chalk, covering ſuch extenſive plains as Lincoln-heath, having become dry without the ſuppoſition of their having been again elevated from the ocean. At the ſame time we acquire the knowledge of one of the uſes or final cauſes of the organized world, not indeed very flattering to our vanity, that it converts water into earth, forming iſlands and continents by its recrements or exuviæ.

## NOTES OMITTED.

*Expiring groans.* p. 73. l. 451. Mr. Savery or Mr. Volney in their Travels through Egypt has given a curious deſcription of one of the pyramids, with the operoſe method of cloſing them, and immuring the body, (as they ſuppoſed) for ſix thouſand years. And has endeavoured from thence to ſhew, that, when a monarch died, ſeveral of his favourite courtiers were incloſed alive with the mummy in theſe great maſſes of ſtone-work; and had food and water conveyed to them, as long as they lived, proper apertures being left for this purpoſe, and for the admiſſion of air, and for the excluſion of any thing offenſive.

*Unfolds his larva-form.* p. 144. l. 458. The flower burſts forth from its larva, the herb, naked and perfect like a butterfly from its chryſolis; winged with its corol; wing-ſheathed by its calyx; conſiſting alone of the organs of reproduction. The males, or ſtamens, have their anthers replete with a prolific powder containing the vivifying fovilla: in the females, or piſtils, exiſts the ovary, terminated by the tubular ſtigma. When the anthers burſt and ſhed their bags of duſt, the male fovilla is received by the prolific lymph of the ſtigma, and produces the ſeed or egg, which is nouriſhed in the ovary. Syſtem of Vegetables tranſlated from Linneus by the Lichfield Society, p. 10.

*Wound them, ye Sylphs!* p. 144. l. 463. It is cuſtomary to debark oak-trees in the ſpring, which are intended to be felled in the enſuing autumn; becauſe the bark comes off eaſier at this ſeaſon, and the ſap-wood, or alburnum, is believed to become harder and more durable, if the tree remains till the end of ſummer. The trees thus ſtripped of their bark put forth ſhoots as uſual with acorns on the 6th, 7th and 8th joint, like vines; but in the branches I examined, the joints of the debarked trees were much ſhorter than thoſe of other oak-trees; the acorns were more numerous; and no new buds were produced above the joints which bore acorns. From hence it appears that the branches of debarked oak-trees produce fewer leaf-buds, and more flower-buds, which laſt circumſtance I ſuppoſe muſt depend on their being ſooner or later debarked in the vernal months. And, ſecondly, that the new buds of debarked oak-trees continue to obtain moiſture from the alburnum after the ſeaſon of the aſcent of ſap in other vegetables ceaſes; which in this unnatural ſtate of the debarked tree may act as capillary tubes, like the alburnum of the ſmall debarked cylinder of a pear-tree abovementioned; or may continue to act as placental veſſels, as happens to the animal embryon in caſes of ſuperfetation; when the fetus continues a month or two in the womb beyond its uſual time, of which ſome inſtances have been recorded, the placenta continues to ſupply perhaps the double office both of nutrition and of reſpiration.

*With new prolific power*. p. 145. l. 467. About Midſummer the new buds are formed, but it is believed by ſome of the Linnean ſchool, that theſe buds may in their early ſtate be either converted into flower-buds or leaf-buds according to the vigour of the vegetating branch. Thus if the upper part of a branch be cut away, the buds near the extremity of the remaining ſtem, having a greater proportional ſupply of nutriment, or poſſeſſing a greater facility of ſhooting their roots, or abſorbent veſſels, down the bark, will become leaf-buds, which might otherwiſe have been flower-buds. And the contrary as explained in note on l. 463. of this Canto.

*Cloſed in the ſtyle*. p. 145. l. 469. "I conceive the medulla of a plant to conſiſt of a bundle of nervous fibres, and that the propelling vital power ſeparates their uppermoſt extremities. Theſe, diverging, penetrate the bark, which is now gelatinous, and become multiplied in the new gem, or leaf-bud. The aſcending veſſels of the bark being thus divided by the nervous fibres, which perforate it, and the aſcent of its fluids being thus impeded, the bark is extended into a leaf. But the flower is produced, when the protruſion of the medulla is greater than the retention of the including cortical part: whence the ſubſtance of the bark is expanded in the calyx; that of the rind, (or interior bark,) in the corol; that of the wood in the ſtamens, that of the medulla in the piſtil. Vegetation thus terminates in the production of new life, the ultimate medullary and cortical fibres being collected in the ſeeds." Linnei Syſtema Veget. p. 6. edit. 14.

*Diana's trees*. p. 150. l. 552. The chemiſts and aſtronomers from the earlieſt antiquity have uſed the ſame characters to repreſent the metals and the planets, which were moſt probably outlines or abſtracts of the original hieroglyphic figures of Egypt. Theſe afterwards acquired niches in their temples, and repreſented Gods as well as metals and planets; whence ſilver is called Diana, or the moon, in the books of alchemy.

The proceſs for making Diana's ſilver tree is thus deſcribed by Lemeri. Diſſolve one ounce of pure ſilver in acid of nitre very pure and moderately ſtrong; mix this ſolution with about twenty ounces of diſtilled water; add to this two ounces of mercury, and let it remain at reſt. In about four days there will form upon the mercury a tree of ſilver with branches imitating vegetation.

1. As the mercury has a greater affinity than ſilver with the nitrous acid, the ſilver becomes precipitated; and, being deprived of the nitrous oxygene by the mercury, ſinks down in its metallic form and luſtre. 2. The attraction between ſilver and mercury, which cauſes them readily to amalgamate together, occaſions the precipitated ſilver to adhere to the ſurface of the mercury in preference to any other part of the veſſel. 3. The attraction of the particles of the precipitated ſilver to each other cauſes the beginning branches to thicken and elongate into trees and ſhrubs rooted on the mercury. For other circumſtances concerning this beautiful experiment ſee Mr. Keir's Chemical Dictionary, art. Ardor Dianæ; a work perhaps of greater utility to mankind than the loſt Alexandrian Library; the continuation of which is ſo eagerly expected by all, who are occupied in the arts, or attached to the ſciences.

# CONTENTS

OF THE

# *ADDITIONAL NOTES.*

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## NOTE I.....METEORS.

THERE are four ſtrata of the atmoſphere, and four kinds of meteors. 1. Lightning is electric, exiſts in viſible clouds, its ſhort courſe, and red light. 2. Shooting ſtars exiſt in inviſible vapour, without ſound, white light, have no luminous trains. 3. Twilight; fire-balls move thirty miles in a ſecond, and are about ſixty miles high, have luminous trains, occaſioned by an electric ſpark paſſing between the aerial and inflammable ſtrata of the atmoſphere, and mixing them and ſetting them on fire in its paſſage; attracted by volcanic eruptions; one thouſand miles through ſuch a medium reſiſts leſs than the tenth of an inch of glaſs. 4. Northern lights not attracted to a point but diffuſed; their colours; paſſage of electric fire in vacuo dubious; Dr. Franklin's theory of northern lights countenanced in part by the ſuppoſition of a ſuperior atmoſphere of inflammable air; antiquity of their appearance; deſcribed in Maccabees.

## NOTE II.....PRIMARY COLOURS.

THE rainbow was in part underſtood before Sir Iſaac Newton; the ſeven colours were diſcovered by him; Mr. Galton's experiments on colours; mangane ſe and lead produce colourleſs glaſs.

## NOTE III.....COLOURED CLOUDS.

THE rays refracted by the convexity of the atmoſphere; the particles of air and of water are blue; ſhadow by means of a candle in the day; halo round the moon in a fog; bright ſpot in the corner of the eye;

light from cat's eyes in the dark, from a horſe's eyes in a cavern, coloured by the choroid coat within the eye.

## NOTE IV.....COMETS.

TAILS of comets from rarified vapour, like northern lights, from electricity; twenty millions of miles long; expected comet.

## NOTE V.....SUN'S RAYS.

DISPUTE about phlogiſton; the ſun the fountain fromwhence all phlogiſton is derived; its rays not luminous till they arrive at our atmoſphere; light owing to their combuſtion with air, whence an unknown acid; the ſun is on fire only on its ſurface; the dark ſpots on it are excavations through its luminous cruſt.

## NOTE VI.....CENTRAL FIRES.

SUN'S heat much leſs than that from the fire at the earth's centre; ſun's heat penetrates but a few feet in ſummer; ſome mines are warm; warm ſprings owing to ſubterraneous fire; ſituations of volcanos on high mountains; original nucleus of the earth; deep vallies of the ocean; diſtant perception of earthquakes; great attraction of mountains; variation of the compaſs; countenance the exiſtence of a cavity or fluid lava within the earth.

## NOTE VII....ELEMENTARY HEAT.

COMBINED and ſenſible heat; chemical combinations attract heat, ſolutions reject heat; ice cools boiling water ſix times as much as cold water cools it; cold produced by evaporation; heat by devaporation; capacities of bodies in reſpect to heat, 1. Exiſtence of the matter of heat ſhewn from the mechanical condenſation and rarefaction of air, from the ſteam produced in exhauſting a receiver, ſnow from rarefied air, cold from diſcharging an air-gun, heat from vibration or friction; 2. Matter of heat analogous to the electric fluid in many circumſtances, explains many chemical phenomena.

## NOTE VIII.....MEMNON'S LYRE.

MECHANICAL impulſe of light dubious; a glaſs tube laid horizontally before a fire revolves; pulſe-glaſs ſuſpended on a centre; black leather contracts in the ſunſhine; Memnon's ſtatue broken by Cambyſes.

## NOTE IX.....LUMINOUS INSECTS.

EIGHTEEN ſpecies of glow-worm, their light owing to their reſpiration in tranſparent lungs; Acudia of Surinam gives light enough to read and draw by, uſe of its light to the inſect; luminous ſea-inſects adhere to the ſkin of thoſe who bathe in the ports of Languedoc, the light may ariſe from putreſcent ſlime.

## NOTE X.....PHOSPHORUS.

DISCOVERED by Kunkel, Brandt, and Boyle; produced in reſpiration, and by luminous inſects, decayed wood, and calcined ſhells; bleaching a ſlow combuſtion in which the water is decompoſed; rancidity of animal fat owing to the decompoſition of water on its ſurface; aerated marine acid does not whiten or bleach the hand.

## NOTE XI.....STEAM-ENGINE.

HERO of Alexandria firſt applied ſteam to machinery, next a French writer in 1630, the Marquis of Worceſter in 1655, Capt. Savery in 1689, Newcomen and Cawley added the piſton; the improvements of Watt and Boulton; power of one of their large engines equal to two hundred horſes.

## NOTE XII.....FROST.

EXPANSION of water in freezing; injury done by vernal froſts; fiſh, eggs, ſeeds, reſiſt congelation; animals do not reſiſt the increaſe of heat; froſts do not meliorate the ground, nor are in general ſalubrious; damp air produces cold on the ſkin by evaporation; ſnow leſs pernicious to agriculture than heavy rains for two reaſons.

## NOTE XIII.....ELECTRICITY.

1. *Points* preferable to knobs for defence of buildings; why points emit the electric fluid; diffuſion of oil on water; mountains are points on the earth's globe; do they produce aſcending currents of air? 2. *Fairy-rings* explained; advantage of paring and burning ground.

## NOTE XIV.....BUDS AND BULBS.

A TREE is a ſwarm of individual plants; vegetables are either oviparous or viviparous; are all annual productions like many kinds of inſects? Hybernacula, a new bark annually produced over the old one in trees and in ſome herbaceous plants, whence their roots ſeem end-bitten; all bulbous roots periſh annually: experiment on a tulip-root; both the leaf-bulbs and the flower-bulbs are annually renewed.

## NOTE XV.....SOLAR VOLCANOS.

THE ſpots in the ſun are cavities, ſome of them four thouſand miles deep and many times as broad; internal parts of the ſun are not in a ſtate of combuſtion; volcanos viſible in the ſun; all the planets together are leſs than one ſix hundred and fiftieth part of the ſun; planets were ejected from the ſun by volcanos; many reaſons ſhewing the probability of this hypotheſis; Mr. Buffon's hypotheſis that planets were ſtruck off from the ſun by comets; why no new planets are ejected from the ſun; ſome comets and the georgium ſidus may be of later date; Sun's matter decreaſed; Mr. Ludlam's opinion, that it is poſſible the moon might be projected from the earth.

## NOTE XVI.....CALCAREOUS EARTH.

HIGH mountains and deep mines replete with ſhells; the earth's nucleus covered with limeſtone; animals convert water into limeſtone; all the calcareous earth in the world formed in animal and vegetable bodies; ſolid parts of the earth increaſe; the water decreaſes; tops of calcareous mountains diſſolved; whence ſpar, marbles, chalk, ſtalactites; whence alabaſter, fluor, flint, granulated limeſtone, from ſolution of their angles, and by attrition; tupha depoſited on moſs; limeſtones from ſhells with animals in them; liver-ſtone from freſh-water muſcles; calcareous earth from land-animals and vegetables, as marl; beds of marble ſoftened by fire; whence Bath-ſtone contains lime as well as limeſtone.

## NOTE XVII.....MORASSES.

THE production of moraſſes from fallen woods; account by the Earl Cromartie of a new moraſs; moraſſes loſe their ſalts by ſolution in water; then their iron; their vegetable acid is converted into marine, nitrous, and vitriolic acids; whence gypſum, alum, ſulphur; into fluor-acid, whence fluor; into ſiliceous acid, whence flint, the ſand of the ſea, and other ſtrata of ſiliceous ſand and marl; ſome moraſſes ferment like new hay, and, ſubliming their phlogiſtic part, form coal-beds above and clay below, which are alſo produced by elutriation; ſhell-fiſh in ſome moraſſes, hence ſhells ſometimes found on coals and over iron-ſtone.

## NOTE XVIII.....IRON.

CALCIFORM ores; combuſtion of iron in vital air; ſteel from deprivation of vital air; welding; hardneſs; brittleneſs like Rupert's drops; ſpecific levity; hardneſs and brittleneſs compared; ſteel tempered by its colours; modern production of iron, manganeſe, calamy; ſeptaria of ironſtone ejected from volcanos; red-hot cannon-balls.

## NOTE XIX.....FLINT.

1. *Siliceous rocks* from moraſſes; their cements. 2. *Siliceous trees;* coloured by iron or manganeſe; Peak-diamonds Briſtol-ſtones; flint in form of calcareous ſpar; has been fluid without much heat; obtained from powdered quartz and fluor-acid by Bergman and by Achard. 3. *Agates and onyxes* found in ſand-rocks; of vegetable origin; have been in complete fuſion; their concentric coloured circles not from ſuperinduction but from congelation; experiment of freezing a ſolution of blue vitriol; iron and manganeſe repelled in ſpheres as the nodule of flint cooled; circular ſtains of marl in ſalt-mines; ſome flint nodules reſemble knots of wood or roots. 4. *Sand of the ſea;* its acid from moraſſes; its baſe from ſhells. 5. *Chert or petroſilex* ſtratified in cooling; their colour and their acid from ſea-animals; labradore-ſtone from mother-pearl. 6. *Flints in chalk-beds;* their form, colour, and acid, from the fleſh of ſea-animals; ſome are hollow and lined with cryſtals; contain iron; not produced by injection from without; coralloids converted to flint; French-millſtones; flints ſometimes found in ſolid ſtrata. 7. *Angles of ſand* deſtroyed by attrition and ſolution in ſteam; ſiliceous breccia cemented by ſolution in red-hot water. 8. *Baſaltes and granites* are antient lavas; baſaltes raiſed by its congelation not by ſubterraneous fire.

## NOTE XX.....CLAY.

FIRE and water two great agents; ſtratification from precipitation; many ſtratified materials not ſoluble in water. 1. Stratification of lava from ſucceſſive accumulation. 2. Stratifications of limeſtone from the different periods of time in which the ſhells were depoſited. 3. Stratifications of coal, and clay, and ſand-ſtone, and iron ores, not from currents of water, but from the production of moraſs-beds at different periods of time; moraſs-beds become ignited; their bitumen and ſulphur is ſublimed, the clay, lime, and iron remain; whence ſand, marle, coal, white clay in valleys, and gravel-beds, and ſome ochres, and ſome calcareous depoſitions owing to alluviation; clay from decompoſed granite; from the lava of Veſuvius; from vitreous lavas.

## NOTE XXI.....ENAMELS.

ROSE-COLOUR and purple from gold; precipitates of gold by alcaline ſalt preferable to thoſe by tin; aurum fulminans long ground; tender colours from gold or iron not diſſolved but ſuſpended in the glaſs; cobalts; calces of cobalt and copper require a ſtrong fire; Ka-o-lin and Pe-tun-tſe the ſame as our own materials.

## NOTE XXII.....PORTLAND VASE.

ITS figures do not allude to private hiſtory; they repreſent a part of the Eluſinian myſteries; marriage of Cupid and Pſyche; proceſſion of torches; the figures in one compartment repreſent MORTAL LIFE in the act of expiring, and HUMANKIND attending to her with concern; Adam and Eve hyeroglyphic figures; Abel and Cain other hyeroglyphic figures; on the other compartment is repreſented IMMORTAL LIFE, the Manes or Ghoſt deſcending into Eliſium is led on by DIVINE LOVE, and received by IMMORTAL LIFE, and conducted to Pluto; Tree of Life and Knowledge are emblematical; the figure at the bottom is of Atis, the firſt great Hierophant, or teacher of myſteries.

## NOTE XXIII.....COAL.

1. A fountain of foſſile tar in Shropſhire; has been diſtilled from the coal-beds beneath, and condenſed in the cavities of a ſand-rock; the coal beneath is deprived of its bitumen in part; bitumen ſublimed at Matlock into cavities lined with ſpar. 2. Coal has been expoſed to heat; woody fibres and vegetable ſeeds in coal at Bovey and Poleſworth; upper part of coal-beds more bituminous at Beaudeſert; thin ſtratum of aſphaltum near Caulk; upper part of coal-bed worſe at Alfreton; upper ſtratum of no value at Widdrington; alum at Weſt-Hallum; at Bilſton. 3. Coal at Coalbrooke-Dale has been immerſed in the ſea, ſhewn by ſea-ſhells; marks of violence in the colliery at Mendip and at Ticknal; Lead-ore and ſpar in coal-beds; gravel over coal near Lichfield; Coal produced from moraſſes ſhewn by fern-leaves, and bog-ſhells, and muſcle-ſhells; by ſome parts of coal being ſtill woody; from Lock Neagh and Bovey, and the Temple of the devil; fixed alcali; oil.

## NOTE XXIV.....GRANITE.

GRANITE the loweſt ſtratum of the earth yet known; porphory, trap, Moor-ſtone, Whin-ſtone, ſlate, baſaltes, all volcanic productions diſſolved in red-hot water; volcanos in granite ſtrata; differ from the heat of moraſſes from fermentation; the nucleus of the earth ejected from the ſun? was the ſun originally a planet? ſuppoſed ſection of the globe.

## NOTE XXV.....EVAPORATION.

I. Solution of water in air; in the matter of heat; pulſe-glaſs. 2. Heat is the principal cauſe of evaporation; thermometer cooled by evaporation of ether; heat given from ſteam to the worm-tub; warmth accompanying rain. 3. Steam condenſed on the eduction of heat; moiſture on cold walls; ſouth-weſt and north-eaſt winds. 4. Solution of ſalt and of blue vitriol in the matter of heat. II. Other vapours may precipitate ſteam and form rain. 1. Cold the principal cauſe of devaporation; hence the ſteam diſſolved in heat is precipitated, but that diſſolved in air remains even in froſts; ſouth-weſt wind. 2. North-eaſt winds mixing with ſouth-weſt winds produce rain; becauſe the cold particles of air of the north-eaſt acquire ſome of the matter of heat from the ſouth-weſt winds. 3. Devaporation from mechanical expanſion of air, as in the receiver of an air-pump; ſummer-clouds appear and vaniſh; when the barometers ſink without change of wind the weather becomes colder. 4. Solution of water in electric fluid dubious. 5. Barometer ſinks from the leſſened gravity of the air, and from the rain having leſs preſſure as it falls; a mixture of a ſolution of water in calorique with an aerial ſolution of water is lighter than dry air; breath of animals in cold weather why condenſed into viſible vapour and diſſolved again.

## NOTE XXVI.....SPRINGS.

LOWEST ſtrata of the earth appear on the higheſt hills; ſprings from dews ſliding between them; mountains are colder than plains; 1. from their being inſulated in the air; 2. from their enlarged ſurface; 3. from the rarety of the air it becomes a better conductor of heat; 4. by the air on mountains being mechanically rarefied as it aſcends; 5. gravitation of the matter of heat; 6. the daſhing of clouds againſt hills; of fogs againſt trees; ſprings ſtronger in hot days with cold nights; ſtreams from ſubterranean caverns; from beneath the ſnow on the Alps.

## NOTE XXVII.....SHELL-FISH.

THE armour of the Echinus moveable; holds itſelf in ſtorms to ſtones by 1200 or 2000 ſtrings: Nautilus rows and ſails; renders its ſhell buoyant: Pinna and Cancer; Byſſus of the antients was the beard of the Pinna; as fine as the ſilk is ſpun by the ſilk-worm; gloves made of it; the beard of muſcles produces ſickneſs; Indian weed; tendons of rats tails.

## NOTE XXVIII.....STURGEON.

STURGEON's mouth like a purſe; without teeth; tendrils like worms hang before his lips, which entice ſmall fiſh and ſea-inſects miſtaking them for worms; his ſkin uſed for covering carriages; iſinglaſs made from it; cavear from the ſpawn.

## NOTE XXIX.....OIL ON WATER.

OIL and water do not touch; a ſecond drop of oil will not diffuſe itſelf on the preceding one; hence itſtills the waves; divers for pearl carry oil in their mouths; oil on water produces priſmatic colours; oiled cork circulates on water; a phial of oil and water made to oſcillate.

## NOTE XXX.....SHIP-WORM.

THE Teredo has calcareous jaws; a new enemy; they periſh when they meet together in their ligneous canals; United Provinces alarmed for the piles of the banks of Zeland; were deſtroyed by a ſevere winter.

## NOTE XXXI.....MAELSTROM.

A WHIRLPOOL on the coaſt of Norway; paſſes through a ſubterraneous cavity; leſs violent when the tide is up; eddies become hollow in the middle; heavy bodies are thrown out by eddies; light ones retained; oil and water whirled in a phial; hurricanes explained.

## NOTE XXXII.....GLACIERS.

SNOW in contact with the earth is in a ſtate of thaw; ice-houſes; rivers from beneath the ſnow; rime in ſpring vaniſhes by its contact with the earth; and ſnow by its evaporation and contact with the earth; moſs vegetates beneath the ſnow; and Alpine plants periſh at Upſal for want of ſnow.

## NOTE XXXIII.....WINDS.

AIR is perpetually ſubject to increaſe and diminution; Oxygene is perpetually produced from vegetables in the ſunſhine, and from clouds in the light, and from water; Azote is perpetually produced from animal and vegetable putrefaction, or combuſtion; from ſprings of water; volatile alcali; fixed alcali; ſea-water; they are both perpetually diminiſhed by their contact with the ſoil, producing nitre; Oxygene is diminiſhed in the production of all acids; Azote by the growth of animal bodies; charcoal in burning conſumes double its weight of pure air; every barrel of red-lead abſorbes 2000 cubic feet of vital air; air obtained from variety of ſubſtances by Dr. Prieſtley; Officina aeris in the polar circle, and at the Line. *South-weſt winds;* their weſterly direction from the leſs velocity of the earth's ſurface; the contrary in reſpect to north-eaſt winds; South-weſt winds conſiſt of regions of air from the ſouth; and north-eaſt winds of regions of air from the north; when the ſouth-weſt prevails for weeks and the barometer ſinks to 28, what becomes of above one fifteenth part of the atmoſphere; 1. It is not carried back by ſuperior currents; 2. Not from its loſs of moiſture; 3. Not carried over the pole; 4. Not owing to atmoſpheric tides or mountains; 5. It is abſorbed at the polar circle; hence ſouth-weſt winds and rain; ſouth-weſt ſometimes cold. *North-eaſt winds* conſiſt of air from the north; cold by the evaporation of ice; are dry winds; 1. Not ſupplied by ſuperior currents; 2. The whole atmoſphere increaſed in quantity by air ſet at liberty from its combinations in the polar circles. *South-eaſt winds* conſiſt of north winds driven back. *North-weſt winds* conſiſt of ſouth-weſt winds driven back; north-weſt winds of America bring froſt; owing to a vertical ſpiral eddy of air between the eaſtern coaſt and the Apalachian mountains; hence the greater cold of North America. *Trade-winds;* air over the Line always hotter than at the tropics; trade-winds gain their eaſterly direction from the greater velocity of the earth's ſurface at the line; not ſupplied by ſuperior currents; ſupplied by decompoſed water in the ſun's great light; 1. Becauſe there are no conſtant rains in the tract of the trade-winds; 2. Becauſe there is no condenſible vapour above three or four miles high at the line. *Monſoons and tornadoes;* ſome places at the tropic become warmer when the ſun is vertical than at the line; hence the air aſcends, ſupplied on one ſide by the north-eaſt winds, and on the other by the ſouth-weſt; whence an aſcending eddy or tornado, raiſing water from the ſea, or ſand from the deſert, and inceſſant rains; air diminiſhed to the northward produces ſouth-weſt winds; tornadoes from heavier air above ſinking through lighter air below, which riſes through a perforation; hence trees are thrown down in a narrow line of twenty or forty yards broad, the ſea riſes like a cone, with great rain and lightning. *Land and Sea breezes;* ſea leſs heated than land; tropical iſlands more heated in the day than the ſea, and are cooled more in the night. *Concluſion;* irregular winds from other cauſes; only two original winds north and ſouth; different ſounds of north-eaſt and ſouth-weſt winds; a Bear or Dragon in the arctic circle that ſwallows at times and diſembogues again above one fifteenth part of the atmoſphere; wind-inſtruments; recapitulation.

## NOTE XXXIV.....VEGETABLE PERSPIRATION.

PURE air from Dr. Prieſtley's vegetable matter, and from vegetable leaves, owing to decompoſition of water; the hydrogene retained by the vegetables; plants in the ſhade are *tanned* green by the ſun's light; animal ſkins are *tanned* yellow by the retention of hydrogene; much pure air from dew on a ſunny morning; bleaching why ſooner performed on cotton than linen; bees wax bleached; metals calcined by decompoſition of water; oil bleached in the light becomes yellow again in the dark; nitrous acid coloured by being expoſed to the ſun; vegetables perſpire more than animals, hence in the ſunſhine they purify air more by their perſpiration than they injure it by their reſpiration; they grow faſteſt in their ſleep.

## NOTE XXXV.....VEGETABLE PLACENTATION.

BUDS the viviparous offspring of vegetables; placentation in bulbs and ſeeds; placentation of buds in the roots, hence the riſing of ſap in the ſpring, as in vines, birch, which ceaſes as ſoon as the leaves expand; production of the leaf of Horſe-cheſnut, and of its new bud; oil of vitriol on the bud of Mimoſa killed the leaf alſo; placentation ſhewn from the ſweetneſs of the ſap; no umbilical artery in vegetables.

## NOTE XXXVI.....VEGETABLE CIRCULATION.

BUDS ſet in the ground will grow if prevented from bleeding to death by a cement; vegetables require no muſcles of locomotion, no ſtomach or bowels, no general ſyſtem of veins; they have, 1. Three ſyſtems of abſorbent veſſels; 2. Two pulmonary ſyſtems; 3. Arterial ſyſtems, 4. Glands; 5. Organs of reproduction; 6. muſcles. I. Abſorbent ſyſtem evinced by experiments by coloured abſorptions in fig-tree and picris; called air-veſſels erroneouſly; ſpiral ſtructure of abſorbent veſſels; retrograde motion of them like the throats of cows. II. Pulmonary arteries in the leaves, and pulmonary veins; no general ſyſtem of veins ſhewn by experiment; no heart; the arteries act like the vena portarum of the liver; pulmonary ſyſtem in the petals of flowers; circulation owing to living irritability; vegetable abſorption more powerful than animal, as in vines; not by capillary attraction.

## NOTE XXXVII.....VEGETABLE RESPIRATION.

I. Leaves not perſpiratory organs, nor excretory ones; lungs of animals. 1. Great ſurfaces of leaves. 2. Vegetable blood changes colour in the leaves; experiment with ſpurge; with picris. 3. Upper ſurface of the leaf only acts as a reſpiratory organ. 4. Upper ſurface repels moiſture; leaves laid on water. 5. Leaves killed by oil like inſects; muſcles at the footſtalks of leaves. 6. Uſe of light to vegetable leaves; experiments of Prieſtley, Ingenhouze, and Scheel. 7. Vegetable circulation ſimilar to that of fiſh. II. Another pulmonary ſyſtem belongs to flowers; colours of flowers. 1. Vaſcular ſtructure of the corol. 2. Glands producing honey, wax, &c. periſh with the corol. 3. Many flowers have no green leaves attending them, as Colchicum. 4. Corols not for the defence of the ſtamens. 5. Corol of Helleborus Niger changes to a calyx. 6. Green leaves not neceſſary to the fruit-bud; green leaves of Colchicum belong to the new bulb not to the flower. 7. Flower-bud after the corol falls is ſimply an uterus; mature flowers not injured by taking of the green leaves. 8. Inoſculation of vegetable veſſels.

## NOTE XXXVIII.....VEGETABLE IMPREGNATION.

SEEDS in broom diſcovered twenty days before the flower opens; progreſs of the ſeed after impregnation; ſeeds exiſt before fecundation; analogy between ſeeds and eggs; progreſs of the egg within the hen; ſpawn of frogs and of fiſh; male Salamander; marine plants project a liquor not a powder; ſeminal fluid diluted with water, if a ſtimulus only? Male and ſemale influence neceſſary in animals, inſects, and vegetables, both in production of ſeeds and buds; does the embryon ſeed produce the ſurrounding fruit, like inſects in gall-nuts?

## NOTE XXIX.....VEGETABLE GLANDULATION.

VEGETABLE glands cannot be injected with coloured fluids; eſſential oil; wax; honey; nectary, its complicate apparatus; expoſes the honey to the air like the lachrymal gland; honey is nutritious; the male and ſemale parts of flowers copulate and die like moths and butterflies, and are fed like them with honey; anthers ſuppoſed to become inſects; depredation of the honey and wax injurious to plants; honey-dew; honey oxygnated by expoſure to air; neceſſary for the production of ſenſibility; the proviſion for the embryon plant of honey, ſugar, ſtarch, &c. ſupplies food to numerous claſſes of animals; various vegetable ſecretions as gum tragacanth, camphor, elemi, anime, turpentine, balſam of Mecca, aloe, myrrh, elaſtic reſin, manna, ſugar, wax, tallow, and many other concrete juices; vegetable digeſtion; chemical production of ſugar would multiply mankind; economy of nature.

THE END.

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